PUBLIC LECTURE SERIES

Hearing The Light: Astronomy Data Sonification

Featuring Guest Speakers:
Scott Fleming, Clara Brasseur, & Jennifer Kotler

1
00:00:05,990 --> 00:00:03,510
hello

2
00:00:06,630 --> 00:00:06,000
and welcome to the space telescope

3
00:00:09,750 --> 00:00:06,640
public

4
00:00:12,470 --> 00:00:09,760
lecture series our talk tonight

5
00:00:14,870 --> 00:00:12,480
hearing the light how sonification

6
00:00:18,630 --> 00:00:14,880
deepens our understanding of the cosmos

7
00:00:20,870 --> 00:00:18,640
and makes astronomy more accessible

8
00:00:21,910 --> 00:00:20,880
i am your host dr frank summers of the

9
00:00:25,269 --> 00:00:21,920
space telescope

10
00:00:26,310 --> 00:00:25,279
science institute and our public lecture

11
00:00:30,870 --> 00:00:26,320
series has been

12
00:00:32,950 --> 00:00:30,880
online only for wow about six months now

13
00:00:34,790 --> 00:00:32,960

and it will continue to be online only

14
00:00:38,150 --> 00:00:34,800
until further notice

15
00:00:40,950 --> 00:00:38,160
that is due to our amazing tech team

16
00:00:41,270 --> 00:00:40,960
thomas marufu and grant justice who take

17
00:00:43,910 --> 00:00:41,280
this

18
00:00:45,670 --> 00:00:43,920
these images and get them out to you on

19
00:00:48,950 --> 00:00:45,680
the internet

20
00:00:50,869 --> 00:00:48,960
upcoming in december

21
00:00:53,189 --> 00:00:50,879
we will have shaping galaxies with

22
00:00:56,229 --> 00:00:53,199
supermassive black hole winds

23
00:00:58,709 --> 00:00:56,239
by mitchell rivolsky and in

24
00:01:00,229 --> 00:00:58,719
january note the special date in january

25
00:01:02,709 --> 00:01:00,239
january 19th

26
00:01:03,349 --> 00:01:02,719
we're avoiding new year's day and we're

27
00:01:05,990 --> 00:01:03,359
also

28
00:01:07,109 --> 00:01:06,000
avoiding the american astronomical

29
00:01:09,429 --> 00:01:07,119
society meeting which

30
00:01:11,350 --> 00:01:09,439
is in early january it's actually a

31
00:01:13,030 --> 00:01:11,360
little later than it usually is so we're

32
00:01:16,070 --> 00:01:13,040
all the way down to january

33
00:01:17,510 --> 00:01:16,080
19th okay we won't be we're usually the

34
00:01:20,070 --> 00:01:17,520
first tuesday but now we're down to

35
00:01:21,510 --> 00:01:20,080
january 19th for when we're doing this

36
00:01:24,070 --> 00:01:21,520
but you're not going to want to miss

37
00:01:26,789 --> 00:01:24,080
that one because that is the darkest

38
00:01:27,510 --> 00:01:26,799

secrets of the universe by raja got the

39
00:01:29,990 --> 00:01:27,520
kurta

40
00:01:31,429 --> 00:01:30,000
at uc santa cruz he's a wonderful guy

41
00:01:33,990 --> 00:01:31,439
i've known him for many years

42
00:01:36,149 --> 00:01:34,000
you're going to want to see that one in

43
00:01:38,469 --> 00:01:36,159
february we will have it on groundhog

44
00:01:40,630 --> 00:01:38,479
day february 2nd

45
00:01:42,630 --> 00:01:40,640
and it will be a fascinating topic by an

46
00:01:46,389 --> 00:01:42,640
amazing speaker that i have yet

47
00:01:47,910 --> 00:01:46,399
to schedule all right uh let's see if

48
00:01:51,230 --> 00:01:47,920
you want to find out all the information

49
00:01:56,069 --> 00:01:52,630
www.stsci.edu

50
00:01:57,910 --> 00:01:56,079
public lectures we'll find this webpage

51
00:02:00,389 --> 00:01:57,920
you can see that there's the links to

52
00:02:02,469 --> 00:02:00,399
the webcast there's also

53
00:02:05,670 --> 00:02:02,479
the link for you to subscribe to our

54
00:02:08,710 --> 00:02:05,680
emails and get our monthly

55
00:02:10,550 --> 00:02:08,720
announcements also on that page are a

56
00:02:12,949 --> 00:02:10,560
list of the upcoming lectures if you've

57
00:02:15,910 --> 00:02:12,959
forgotten what's coming up next month

58
00:02:17,750 --> 00:02:15,920
as well as each one of those lectures

59
00:02:18,550 --> 00:02:17,760
has all sorts of details about the

60
00:02:21,510 --> 00:02:18,560
speaker

61
00:02:22,390 --> 00:02:21,520
and the topic as well as after it has

62
00:02:24,470 --> 00:02:22,400
gone through

63
00:02:27,589 --> 00:02:24,480

you can see we have the link to the

64
00:02:30,070 --> 00:02:27,599
webcast on the sdsci webcasting site

65
00:02:32,470 --> 00:02:30,080
as well as the link to the webcast on

66
00:02:35,030 --> 00:02:32,480
youtube

67
00:02:36,790 --> 00:02:35,040
our email announcements as i said the

68
00:02:39,990 --> 00:02:36,800
easiest thing to do is just sign up

69
00:02:41,509 --> 00:02:40,000
at the website you can also subscribe to

70
00:02:43,670 --> 00:02:41,519
our youtube channel

71
00:02:45,270 --> 00:02:43,680
because all of these uh lectures are

72
00:02:48,309 --> 00:02:45,280
being posted to youtube

73
00:02:49,670 --> 00:02:48,319
youtube.com hubble space telescope all

74
00:02:51,509 --> 00:02:49,680
one word

75
00:02:53,670 --> 00:02:51,519
if you subscribe to that you'll get

76
00:02:56,790 --> 00:02:53,680
notices of our new videos

77
00:02:58,550 --> 00:02:56,800
and reminders of live events like this

78
00:03:00,149 --> 00:02:58,560
and finally if you have comments or

79
00:03:00,869 --> 00:03:00,159
questions you can send them to public

80
00:03:04,229 --> 00:03:00,879
lecture

81
00:03:07,270 --> 00:03:04,239
at stsci.edu

82
00:03:08,470 --> 00:03:07,280
our social media that uh well we've got

83
00:03:09,350 --> 00:03:08,480
social media for the hubble space

84
00:03:14,070 --> 00:03:09,360
telescope

85
00:03:16,710 --> 00:03:14,080
launches less than one year away

86
00:03:17,990 --> 00:03:16,720
we're one year away from launch update

87
00:03:21,030 --> 00:03:18,000
the james webb space telescope

88
00:03:22,229 --> 00:03:21,040

we're excited about that uh we also have

89
00:03:24,309 --> 00:03:22,239
social media for the

90
00:03:25,589 --> 00:03:24,319
just our institute space telescope

91
00:03:27,430 --> 00:03:25,599
science institute

92
00:03:29,750 --> 00:03:27,440
uh facebook twitter youtube and

93
00:03:32,070 --> 00:03:29,760
instagram as listed there

94
00:03:33,030 --> 00:03:32,080
myself i only do a tiny amount of social

95
00:03:34,630 --> 00:03:33,040
media

96
00:03:36,949 --> 00:03:34,640
i'm going to do a little bit on facebook

97
00:03:38,789 --> 00:03:36,959
and a little bit on twitter

98
00:03:40,630 --> 00:03:38,799
you won't be inundated if you follow me

99
00:03:41,270 --> 00:03:40,640
you'll just get things every now and

100
00:03:44,470 --> 00:03:41,280
then

101
00:03:47,110 --> 00:03:44,480
okay so now

102
00:03:47,509 --> 00:03:47,120
our news from the universe for november

103
00:03:55,350 --> 00:03:47,519
to

104
00:03:58,470 --> 00:03:55,360
getting the big picture and we mean

105
00:04:00,309 --> 00:03:58,480
big picture all right so there's a new

106
00:04:04,789 --> 00:04:00,319
observatory going in

107
00:04:07,110 --> 00:04:04,799
in chile upon the sierra talolo in chile

108
00:04:08,309 --> 00:04:07,120
this is the reuben observatory named

109
00:04:11,270 --> 00:04:08,319
after the astronomer

110
00:04:12,390 --> 00:04:11,280
vera rubin and this is an image of it as

111
00:04:15,589 --> 00:04:12,400
it existed

112
00:04:18,469 --> 00:04:15,599
as it was in may of this year and it's

113
00:04:19,830 --> 00:04:18,479

progressing really well um they will

114
00:04:22,469 --> 00:04:19,840
start data taking

115
00:04:23,189 --> 00:04:22,479
sometime next year and they'll actually

116
00:04:26,950 --> 00:04:23,199
move into

117
00:04:29,670 --> 00:04:26,960
actually operational in 2022 i believe

118
00:04:30,710 --> 00:04:29,680
now this has got a huge mirror in it

119
00:04:33,830 --> 00:04:30,720
okay

120
00:04:34,710 --> 00:04:33,840
this is the mirror blank before it was

121
00:04:36,469 --> 00:04:34,720
aluminized

122
00:04:37,749 --> 00:04:36,479
uh to have its reflective surface it's

123
00:04:40,070 --> 00:04:37,759
an eight

124
00:04:41,110 --> 00:04:40,080
meters across this image just shows you

125
00:04:43,749 --> 00:04:41,120
just how

126
00:04:45,189 --> 00:04:43,759
huge this mirror is you can do that in a

127
00:04:48,550 --> 00:04:45,199
ground-based telescope

128
00:04:49,189 --> 00:04:48,560
and with a mirror this big you also need

129
00:04:52,710 --> 00:04:49,199
to have

130
00:04:53,790 --> 00:04:52,720
a big detector well they have one and

131
00:04:57,590 --> 00:04:53,800
it's called

132
00:05:00,710 --> 00:04:57,600
lsst cam all right and this is a

133
00:05:04,070 --> 00:05:00,720
combination of many many

134
00:05:04,469 --> 00:05:04,080
ccds put together at the prime focus of

135
00:05:07,590 --> 00:05:04,479
the

136
00:05:11,270 --> 00:05:07,600
rubin telescope and it is it's

137
00:05:13,110 --> 00:05:11,280
just an amazing a new detector

138
00:05:14,550 --> 00:05:13,120

okay so here are some characteristics of

139
00:05:17,909 --> 00:05:14,560
lsst cam

140
00:05:21,590 --> 00:05:17,919
first of all the field of view is seven

141
00:05:22,469 --> 00:05:21,600
full moons across okay it's 40 full

142
00:05:25,510 --> 00:05:22,479
moons across

143
00:05:28,710 --> 00:05:25,520
the whole detector that is

144
00:05:29,029 --> 00:05:28,720
huge there is a huge field of view but

145
00:05:31,909 --> 00:05:29,039
it

146
00:05:33,270 --> 00:05:31,919
also has incredible resolution as you

147
00:05:35,110 --> 00:05:33,280
can see on the right

148
00:05:36,790 --> 00:05:35,120
they've got this picture where you can't

149
00:05:37,590 --> 00:05:36,800
really see is there a golf course in

150
00:05:39,909 --> 00:05:37,600
there somewhere

151
00:05:42,310 --> 00:05:39,919
yes there is obviously and they can

152
00:05:44,310 --> 00:05:42,320
actually resolve the golf ball on the

153
00:05:45,029 --> 00:05:44,320
golf course they say they can see a golf

154
00:05:48,070 --> 00:05:45,039
ball

155
00:05:50,870 --> 00:05:48,080
from 15 miles away

156
00:05:52,550 --> 00:05:50,880
all right now it's great resolution

157
00:05:54,230 --> 00:05:52,560
especially for ground based but you know

158
00:05:55,110 --> 00:05:54,240
you know ground base does have its

159
00:05:57,430 --> 00:05:55,120
limits

160
00:05:59,270 --> 00:05:57,440
um hubble will have has four times

161
00:06:01,350 --> 00:05:59,280
better resolution than lsst

162
00:06:02,870 --> 00:06:01,360
cam but hey hubble's in space hubble

163
00:06:03,830 --> 00:06:02,880

doesn't have the atmosphere to look

164
00:06:07,029 --> 00:06:03,840
through so

165
00:06:07,749 --> 00:06:07,039
you know it's it does amazing things

166
00:06:11,270 --> 00:06:07,759
it's going to be

167
00:06:11,590 --> 00:06:11,280
huge and so this detector that i showed

168
00:06:14,390 --> 00:06:11,600
you

169
00:06:15,430 --> 00:06:14,400
is now operational and they wanted to

170
00:06:18,790 --> 00:06:15,440
test it

171
00:06:21,590 --> 00:06:18,800
so they did a um

172
00:06:22,070 --> 00:06:21,600
they did a pit hole camera to just test

173
00:06:26,950 --> 00:06:22,080
it

174
00:06:30,469 --> 00:06:26,960
and this is one of their test images 3.2

175
00:06:31,990 --> 00:06:30,479
billion pixels 3.2 gigapixels right

176
00:06:33,590 --> 00:06:32,000
you know i mean you may be impressed

177
00:06:34,950 --> 00:06:33,600
that your phone has you know

178
00:06:37,670 --> 00:06:34,960
we used to be impressed that our phones

179
00:06:41,830 --> 00:06:37,680
had one megapixel or five megapixel

180
00:06:44,870 --> 00:06:41,840
10 megapixel 40 megapixels no no 3.2

181
00:06:46,710 --> 00:06:44,880
gigapixels here okay uh this

182
00:06:48,390 --> 00:06:46,720
image that they use to test it is

183
00:06:51,430 --> 00:06:48,400
actually vera rubin

184
00:06:53,110 --> 00:06:51,440
um processing some of her data

185
00:06:54,870 --> 00:06:53,120
and they took that image they use a

186
00:06:55,990 --> 00:06:54,880
pinhole camera to spread it out across

187
00:06:58,629 --> 00:06:56,000
the entire thing

188
00:06:59,029 --> 00:06:58,639

to get a test image all right and so

189
00:07:01,430 --> 00:06:59,039
they

190
00:07:02,230 --> 00:07:01,440
now are beginning to characterize the

191
00:07:04,150 --> 00:07:02,240
detector

192
00:07:06,390 --> 00:07:04,160
they're being able to figure out all of

193
00:07:09,189 --> 00:07:06,400
the various uh details of it

194
00:07:09,749 --> 00:07:09,199
and showing that they really do have 3.2

195
00:07:12,390 --> 00:07:09,759
billion

196
00:07:13,350 --> 00:07:12,400
pixels to work with um and and this

197
00:07:15,510 --> 00:07:13,360
really you know

198
00:07:17,909 --> 00:07:15,520
it made me sort of think about wow where

199
00:07:20,870 --> 00:07:17,919
are we going to go in the next decade

200
00:07:21,990 --> 00:07:20,880
all right so um this is a hubble image

201
00:07:25,110 --> 00:07:22,000
right

202
00:07:27,510 --> 00:07:25,120
this is a hubble image of stars uh in

203
00:07:29,589 --> 00:07:27,520
the andromeda galaxy

204
00:07:31,589 --> 00:07:29,599
and there's so much detail in a hubble

205
00:07:32,230 --> 00:07:31,599
image but as you can see on the right

206
00:07:35,110 --> 00:07:32,240
that's a

207
00:07:37,430 --> 00:07:35,120
tiny tiny region in the halo of the

208
00:07:39,589 --> 00:07:37,440
andromeda galaxy okay

209
00:07:41,909 --> 00:07:39,599
for hubble to see the entire galaxy it

210
00:07:44,790 --> 00:07:41,919
would be really really difficult

211
00:07:47,270 --> 00:07:44,800
but we tried we tried we actually did

212
00:07:50,390 --> 00:07:47,280
make a hubble mosaic

213
00:07:51,909 --> 00:07:50,400

called the panchromatic hubble andromeda

214
00:07:54,950 --> 00:07:51,919
treasury program or the fat

215
00:07:57,909 --> 00:07:54,960
program and at orange square

216
00:07:58,670 --> 00:07:57,919
that's one hubble detector and we had to

217
00:08:02,230 --> 00:07:58,680
take like

218
00:08:04,950 --> 00:08:02,240
300 images to cover basically about

219
00:08:06,230 --> 00:08:04,960
one third of the andromeda galaxy as you

220
00:08:08,230 --> 00:08:06,240
see on the right

221
00:08:09,589 --> 00:08:08,240
so hubble has been able to cover that

222
00:08:12,390 --> 00:08:09,599
much

223
00:08:13,110 --> 00:08:12,400
and if you came to our previous talks

224
00:08:15,589 --> 00:08:13,120
about the

225
00:08:16,629 --> 00:08:15,599
uh the rome the what used to be called

226
00:08:19,670 --> 00:08:16,639
the w first

227
00:08:21,430 --> 00:08:19,680
uh is now the roman space telescope um

228
00:08:22,710 --> 00:08:21,440
you can see that we you know learned

229
00:08:26,869 --> 00:08:22,720
that the roman

230
00:08:29,430 --> 00:08:26,879
telescope has 18 different detectors

231
00:08:31,270 --> 00:08:29,440
spread out over a much larger region and

232
00:08:33,750 --> 00:08:31,280
that roman as shown on the right

233
00:08:34,709 --> 00:08:33,760
can do all that hubble did in its 300 or

234
00:08:37,750 --> 00:08:34,719
so pointings

235
00:08:40,230 --> 00:08:37,760
in like two or three pointings so roman

236
00:08:43,750 --> 00:08:40,240
will have a huge field of view but

237
00:08:44,630 --> 00:08:43,760
even that is not the same as what reuben

238
00:08:48,630 --> 00:08:44,640

will have

239
00:08:51,430 --> 00:08:48,640
because when we compare roman to ruben

240
00:08:53,670 --> 00:08:51,440
rubin will be able to get the entire

241
00:08:57,430 --> 00:08:53,680
andromeda galaxy in

242
00:08:57,750 --> 00:08:57,440
one image wow that's what we're gonna

243
00:08:59,829 --> 00:08:57,760
get

244
00:09:01,910 --> 00:08:59,839
we're gonna go from you know these 16

245
00:09:03,350 --> 00:09:01,920
megapixels images from hubble

246
00:09:05,350 --> 00:09:03,360
and we put them all together to make

247
00:09:06,310 --> 00:09:05,360
them even bigger but we're going to get

248
00:09:09,670 --> 00:09:06,320
3.2

249
00:09:12,870 --> 00:09:09,680
billion pixels with every image from

250
00:09:15,350 --> 00:09:12,880
the reuben telescope we're going to have

251
00:09:17,509 --> 00:09:15,360
a smorgasbord of data

252
00:09:20,070 --> 00:09:17,519
over the next couple over the next

253
00:09:24,710 --> 00:09:22,870
our second story tonight it's the

254
00:09:27,829 --> 00:09:24,720
greater pumpkin edwin

255
00:09:29,670 --> 00:09:27,839
hubble uh okay all right so

256
00:09:30,949 --> 00:09:29,680
uh some we have a lot of international

257
00:09:32,230 --> 00:09:30,959
viewers and they may not get the

258
00:09:34,630 --> 00:09:32,240
reference um

259
00:09:37,190 --> 00:09:34,640
in the united states uh we have a

260
00:09:38,870 --> 00:09:37,200
tradition of a halloween

261
00:09:40,710 --> 00:09:38,880
program called it's the great pumpkin

262
00:09:43,110 --> 00:09:40,720
charlie brown i think peanuts is

263
00:09:46,870 --> 00:09:43,120

probably worldwide but

264
00:09:50,389 --> 00:09:46,880
this tv program came out in 1966

265
00:09:52,630 --> 00:09:50,399
and our news chief decided well

266
00:09:53,829 --> 00:09:52,640
we gotta have some sort of tie-in for

267
00:09:56,389 --> 00:09:53,839
halloween

268
00:09:57,269 --> 00:09:56,399
so we found an image and it sort of

269
00:10:00,470 --> 00:09:57,279
looks like a

270
00:10:04,389 --> 00:10:00,480
pumpkin and what it and here is that

271
00:10:09,269 --> 00:10:04,399
image these are the interacting galaxies

272
00:10:11,509 --> 00:10:09,279
ngc 2292 and 2293

273
00:10:13,430 --> 00:10:11,519
what you've got going on here is those

274
00:10:15,670 --> 00:10:13,440
white eyes those are the cores of the

275
00:10:18,069 --> 00:10:15,680
galaxies that are mixing together

276
00:10:20,230 --> 00:10:18,079
and all the other material around it as

277
00:10:23,110 --> 00:10:20,240
the galaxies as they've smashed together

278
00:10:24,230 --> 00:10:23,120
and are now mixing it up and down bottom

279
00:10:25,910 --> 00:10:24,240
you see the dark

280
00:10:27,269 --> 00:10:25,920
dust lane okay that dust lane there's a

281
00:10:29,670 --> 00:10:27,279
little bit of star formation going on

282
00:10:32,870 --> 00:10:29,680
this thing that sort of forms the smile

283
00:10:34,389 --> 00:10:32,880
of the jack-o-lantern okay um and

284
00:10:35,750 --> 00:10:34,399
when they found this they said all right

285
00:10:36,389 --> 00:10:35,760
we got to do this for a halloween

286
00:10:37,990 --> 00:10:36,399
release

287
00:10:39,350 --> 00:10:38,000
and it looks sort of like a pumpkin so

288
00:10:41,190 --> 00:10:39,360

we'll call it it's they call it the

289
00:10:43,829 --> 00:10:41,200
greater pumpkin

290
00:10:44,710 --> 00:10:43,839
i actually think it looks a little bit

291
00:10:51,110 --> 00:10:44,720
more

292
00:10:53,110 --> 00:10:51,120
jack skellington from the nightmare

293
00:10:55,430 --> 00:10:53,120
before christmas

294
00:10:56,389 --> 00:10:55,440
but i guess making the jack skellington

295
00:10:59,430 --> 00:10:56,399
reference isn't the same

296
00:11:02,230 --> 00:10:59,440
although he is the pumpkin king but

297
00:11:02,949 --> 00:11:02,240
that was our halloween release uh to

298
00:11:05,590 --> 00:11:02,959
show off

299
00:11:07,110 --> 00:11:05,600
uh the interacting galaxies and how cool

300
00:11:09,110 --> 00:11:07,120
they can look

301
00:11:11,350 --> 00:11:09,120
all right we have one more story for you

302
00:11:15,310 --> 00:11:11,360
and it's a really special one

303
00:11:18,389 --> 00:11:15,320
we are celebrating a century of cosmic

304
00:11:19,590 --> 00:11:18,399
inquisitivity now i've been doing the

305
00:11:22,069 --> 00:11:19,600
public lecture series

306
00:11:23,269 --> 00:11:22,079
for almost 20 years now 19 years i have

307
00:11:25,430 --> 00:11:23,279
been hosting it

308
00:11:26,389 --> 00:11:25,440
and most of my time that i've been

309
00:11:29,190 --> 00:11:26,399
hosting it

310
00:11:30,310 --> 00:11:29,200
i have seen one particular member of the

311
00:11:34,230 --> 00:11:30,320
audience

312
00:11:38,550 --> 00:11:34,240
down in the front row and she has just

313
00:11:41,670 --> 00:11:38,560

turned 100 years old so we are going to

314
00:11:43,030 --> 00:11:41,680
shout out to molly watau from baltimore

315
00:11:46,230 --> 00:11:43,040
maryland who is

316
00:11:48,710 --> 00:11:46,240
100 years young this month okay

317
00:11:50,310 --> 00:11:48,720
molly is amazing she comes to the public

318
00:11:50,550 --> 00:11:50,320
lecture series when we're able to have

319
00:11:56,790 --> 00:11:50,560
it

320
00:11:59,910 --> 00:11:56,800
she's told me that she's gone and seen

321
00:12:03,030 --> 00:11:59,920
several solar eclipses over her life

322
00:12:05,269 --> 00:12:03,040
and so i was gonna sing for you guys but

323
00:12:06,150 --> 00:12:05,279
you know you really don't want that i'm

324
00:12:09,190 --> 00:12:06,160
not a singer

325
00:12:13,190 --> 00:12:09,200
but i am a visualizer

326
00:12:16,550 --> 00:12:13,200
so molly for your birthday we have

327
00:12:31,190 --> 00:12:16,560
an observation of the birthday cake

328
00:12:34,870 --> 00:12:33,670
happy birthday molly everybody go to the

329
00:12:36,470 --> 00:12:34,880
chat on youtube

330
00:12:38,069 --> 00:12:36,480
and type in your happy birthday

331
00:12:40,710 --> 00:12:38,079
congratulations from molly

332
00:12:42,230 --> 00:12:40,720
who is a hundred years old this month

333
00:12:44,150 --> 00:12:42,240
all right

334
00:12:45,670 --> 00:12:44,160
let's get back to our regularly

335
00:12:47,430 --> 00:12:45,680
scheduled program

336
00:12:49,269 --> 00:12:47,440
hearing the light how sonification

337
00:12:52,470 --> 00:12:49,279
deepens our understanding of the cosmos

338
00:12:54,389 --> 00:12:52,480

and makes astronomy more accessible i'm

339
00:12:58,230 --> 00:12:54,399
going to stop my screen share while i

340
00:13:01,750 --> 00:13:01,030
so we have uh scott fleming clara

341
00:13:04,389 --> 00:13:01,760
brasser

342
00:13:06,470 --> 00:13:04,399
and jen cutler who are going to be

343
00:13:08,949 --> 00:13:06,480
speaking here tonight

344
00:13:09,910 --> 00:13:08,959
scott is a senior astronomical data

345
00:13:12,790 --> 00:13:09,920
science working

346
00:13:14,150 --> 00:13:12,800
in the mast archive that is the mikulski

347
00:13:14,629 --> 00:13:14,160
archive for space telescopes it's where

348
00:13:16,870 --> 00:13:14,639
we keep

349
00:13:18,550 --> 00:13:16,880
all the data from both hubble and lots

350
00:13:20,949 --> 00:13:18,560
of other space telescopes

351
00:13:24,150 --> 00:13:20,959
he received his phd in astronomy from

352
00:13:26,470 --> 00:13:24,160
the university of florida in 2011

353
00:13:27,590 --> 00:13:26,480
and his research interests are in extra

354
00:13:30,470 --> 00:13:27,600
exoplanets

355
00:13:32,550 --> 00:13:30,480
and stellar astrophysics our second

356
00:13:34,870 --> 00:13:32,560
speaker is clara brassur

357
00:13:36,949 --> 00:13:34,880
she is a senior software engineer at the

358
00:13:39,670 --> 00:13:36,959
space telescope science institute

359
00:13:40,470 --> 00:13:39,680
she primarily builds python tools for

360
00:13:43,189 --> 00:13:40,480
astronomical

361
00:13:45,350 --> 00:13:43,199
data access and also performs research

362
00:13:48,629 --> 00:13:45,360
on stellar flares

363
00:13:51,829 --> 00:13:48,639

our third speaker tonight is jen cottler

364
00:13:54,629 --> 00:13:51,839
she leads user experience design

365
00:13:56,949 --> 00:13:54,639
at the mast archive she is passionate

366
00:13:59,509 --> 00:13:56,959
about using design and open technology

367
00:14:01,430 --> 00:13:59,519
to make science accessible to everyone

368
00:14:02,870 --> 00:14:01,440
and these three wonderful people have

369
00:14:05,910 --> 00:14:02,880
collaborated on this

370
00:14:07,590 --> 00:14:05,920
really amazing project uh and so i will

371
00:14:09,269 --> 00:14:07,600
turn it over to you scott you are

372
00:14:11,910 --> 00:14:09,279
speaking first right

373
00:14:13,030 --> 00:14:11,920
ladies and gentlemen scott fleming yes

374
00:14:15,829 --> 00:14:13,040
that's right

375
00:14:16,949 --> 00:14:15,839
we'll have to get the slides up here

376
00:14:23,110 --> 00:14:16,959
welcome everyone

377
00:14:23,990 --> 00:14:23,120
archive on youtube and an extra special

378
00:14:27,670 --> 00:14:24,000
welcome

379
00:14:30,790 --> 00:14:27,680
to all of you attending the live stream

380
00:14:34,710 --> 00:14:30,800
um i'm really excited to to give a talk

381
00:14:38,310 --> 00:14:34,720
today about our work on sonifying

382
00:14:40,870 --> 00:14:38,320
astronomical data this is going to be

383
00:14:42,230 --> 00:14:40,880
a team presentation so i'm dr scott

384
00:14:44,870 --> 00:14:42,240
fleming

385
00:14:46,230 --> 00:14:44,880
i'm here with two other team members on

386
00:14:49,189 --> 00:14:46,240
the astronomify team

387
00:14:49,590 --> 00:14:49,199
clara and jen i'm going to pause and let

388
00:14:56,949 --> 00:14:49,600

them

389
00:15:01,189 --> 00:14:59,750
um hi i'm clara bursser i'm the lead

390
00:15:04,870 --> 00:15:01,199
developer on this project

391
00:15:07,269 --> 00:15:04,880
um so i uh have been

392
00:15:08,870 --> 00:15:07,279
running all the software that we're used

393
00:15:10,150 --> 00:15:08,880
to make all of the

394
00:15:12,550 --> 00:15:10,160
sounds that you'll be hearing throughout

395
00:15:14,870 --> 00:15:12,560
this presentation

396
00:15:20,870 --> 00:15:14,880
hey guys kill the screen share if you're

397
00:15:25,750 --> 00:15:24,150
and hi i'm jen cutler and i'm

398
00:15:27,829 --> 00:15:25,760
as i mentioned a user experience

399
00:15:29,670 --> 00:15:27,839
designer so i'm focusing on the

400
00:15:31,509 --> 00:15:29,680
usability and doing testing

401
00:15:33,030 --> 00:15:31,519
for all the sonifications that you'll

402
00:15:35,509 --> 00:15:33,040
hear today and

403
00:15:38,829 --> 00:15:35,519
also working on some outreach exhibits

404
00:15:40,710 --> 00:15:38,839
to try to share this with a wider

405
00:15:42,310 --> 00:15:40,720
audience

406
00:15:44,790 --> 00:15:42,320
all right so we'll get the slides back

407
00:15:45,430 --> 00:15:44,800
up and uh the talk will be in three

408
00:15:48,230 --> 00:15:45,440
parts

409
00:15:49,829 --> 00:15:48,240
uh i'm going to uh first do an

410
00:15:51,990 --> 00:15:49,839
introduction and a background on the

411
00:15:54,069 --> 00:15:52,000
project and about sonification

412
00:15:56,790 --> 00:15:54,079
clara is going to show you some

413
00:15:57,829 --> 00:15:56,800

astrophysical examples of sonophyte data

414
00:16:00,710 --> 00:15:57,839
and then

415
00:16:02,949 --> 00:16:00,720
hopefully the best part jen will walk us

416
00:16:04,710 --> 00:16:02,959
through a game show where you'll be able

417
00:16:08,949 --> 00:16:04,720
to try to test your ears

418
00:16:11,110 --> 00:16:08,959
and see if you can hear the uh sonified

419
00:16:12,710 --> 00:16:11,120
data and signals from some of these uh

420
00:16:13,990 --> 00:16:12,720
astrophysical objects that were turning

421
00:16:16,710 --> 00:16:14,000
into sound

422
00:16:17,509 --> 00:16:16,720
so before i begin one more important

423
00:16:19,749 --> 00:16:17,519
point

424
00:16:21,430 --> 00:16:19,759
this is going to feature a lot of sound

425
00:16:22,949 --> 00:16:21,440
unlike some of the other presentations

426
00:16:25,430 --> 00:16:22,959
and so if you do have

427
00:16:26,790 --> 00:16:25,440
some headphones or the ability to turn

428
00:16:28,470 --> 00:16:26,800
up your volume a little bit

429
00:16:30,949 --> 00:16:28,480
you may want to do so so you can hear

430
00:16:34,230 --> 00:16:30,959
the sounds as well as possible

431
00:16:36,949 --> 00:16:34,240
okay so i already introduced myself

432
00:16:37,590 --> 00:16:36,959
and i i'm the principal investigator and

433
00:16:47,030 --> 00:16:37,600
the

434
00:16:50,230 --> 00:16:47,040
education

435
00:16:53,350 --> 00:16:50,240
specialists

436
00:16:57,350 --> 00:16:53,360
and is a very important uh part of our

437
00:16:59,509 --> 00:16:57,360
our team here okay

438
00:17:00,710 --> 00:16:59,519

so i want to first talk about what

439
00:17:03,430 --> 00:17:00,720
sonification is

440
00:17:05,669 --> 00:17:03,440
because it's probably a term that not a

441
00:17:09,189 --> 00:17:05,679
lot of you have heard before

442
00:17:10,470 --> 00:17:09,199
and i want to start off by telling you

443
00:17:18,789 --> 00:17:10,480
what sonification

444
00:17:21,909 --> 00:17:18,799
is not is it's not sounds themselves

445
00:17:23,829 --> 00:17:21,919
so for example ocean scientists

446
00:17:25,429 --> 00:17:23,839
use something called hydrophones you see

447
00:17:27,429 --> 00:17:25,439
a picture of one on the upper left it's

448
00:17:30,150 --> 00:17:27,439
basically a very sensitive

449
00:17:31,029 --> 00:17:30,160
microphone that they put under the water

450
00:17:33,350 --> 00:17:31,039
and record

451
00:17:34,630 --> 00:17:33,360
sounds to study what what's what they

452
00:17:37,590 --> 00:17:34,640
are and what's making them

453
00:17:38,710 --> 00:17:37,600
so some examples might be a distant ship

454
00:17:41,270 --> 00:17:38,720
uh it could be

455
00:17:43,029 --> 00:17:41,280
whale songs it could be dolphin

456
00:17:44,870 --> 00:17:43,039
communication it could be undersea

457
00:17:48,549 --> 00:17:44,880
earthquakes and volcanoes

458
00:17:52,470 --> 00:17:48,559
but they are recording sounds to analyze

459
00:17:55,669 --> 00:17:52,480
in other words the sounds are the data

460
00:17:57,909 --> 00:17:55,679
when we talk about sonification what

461
00:18:01,110 --> 00:17:57,919
we're really doing is we're representing

462
00:18:01,669 --> 00:18:01,120
other types of data as sound and you're

463
00:18:04,310 --> 00:18:01,679

already

464
00:18:05,909 --> 00:18:04,320
used to this from a visual perspective

465
00:18:08,710 --> 00:18:05,919
we've all seen things like bar

466
00:18:09,510 --> 00:18:08,720
charts and pie charts and trend lines

467
00:18:12,150 --> 00:18:09,520
and

468
00:18:13,669 --> 00:18:12,160
weather maps so these are all ways that

469
00:18:16,310 --> 00:18:13,679
you can

470
00:18:17,270 --> 00:18:16,320
you know represent things like how hot

471
00:18:20,230 --> 00:18:17,280
it is outside

472
00:18:20,870 --> 00:18:20,240
or what the stock prices are doing or

473
00:18:22,549 --> 00:18:20,880
how many

474
00:18:24,230 --> 00:18:22,559
products a certain person may have

475
00:18:27,590 --> 00:18:24,240
bought in the store

476
00:18:29,669 --> 00:18:27,600
as graphs or maps

477
00:18:30,870 --> 00:18:29,679
and in our case what we're doing is

478
00:18:32,950 --> 00:18:30,880
representing

479
00:18:34,710 --> 00:18:32,960
other types of data as sound instead of

480
00:18:37,029 --> 00:18:34,720
these more visual methods

481
00:18:38,710 --> 00:18:37,039
and that is what sonification is so why

482
00:18:40,310 --> 00:18:38,720
do we want to do this why do we want to

483
00:18:42,070 --> 00:18:40,320
sonify data in the first place

484
00:18:44,310 --> 00:18:42,080
there's three main important points for

485
00:18:47,510 --> 00:18:44,320
sonifying data

486
00:18:48,789 --> 00:18:47,520
the first one is about sensitivity so it

487
00:18:51,350 --> 00:18:48,799
turns out that

488
00:18:52,870 --> 00:18:51,360

most human ears can distinguish

489
00:18:54,630 --> 00:18:52,880
something like 1300 different

490
00:18:56,950 --> 00:18:54,640
frequencies

491
00:18:58,950 --> 00:18:56,960
and the human ear is very sensitive the

492
00:19:01,190 --> 00:18:58,960
human ear can actually detect

493
00:19:02,310 --> 00:19:01,200
changes of sound at the micro second

494
00:19:05,909 --> 00:19:02,320
level that's

495
00:19:09,590 --> 00:19:05,919
one one millionth of a second

496
00:19:11,590 --> 00:19:09,600
and if you're a fan of video games or

497
00:19:13,350 --> 00:19:11,600
movies like i am

498
00:19:15,990 --> 00:19:13,360
visually you'll know that a lot of

499
00:19:18,549 --> 00:19:16,000
monitors and television screens

500
00:19:19,750 --> 00:19:18,559
typically are what we call 60 fps frames

501
00:19:21,430 --> 00:19:19,760
per second or maybe

502
00:19:23,669 --> 00:19:21,440
the top of the line ones are trying to

503
00:19:25,270 --> 00:19:23,679
go out to 120 frames per second

504
00:19:27,270 --> 00:19:25,280
but it's something like about a hundred

505
00:19:27,990 --> 00:19:27,280
frames per second and there's a reason

506
00:19:30,310 --> 00:19:28,000
why

507
00:19:32,470 --> 00:19:30,320
companies haven't bothered making you

508
00:19:33,590 --> 00:19:32,480
know thousand frame per second monitors

509
00:19:35,430 --> 00:19:33,600
or a million frame

510
00:19:37,190 --> 00:19:35,440
because the human eye just can't see it

511
00:19:39,029 --> 00:19:37,200
it turns out so

512
00:19:40,549 --> 00:19:39,039
you know visually we're sensitive to

513
00:19:41,669 --> 00:19:40,559

things that like the hundred frames per

514
00:19:43,669 --> 00:19:41,679
second level but

515
00:19:45,190 --> 00:19:43,679
audio wise our ears can detect things

516
00:19:48,230 --> 00:19:45,200
much changing at a much

517
00:19:50,070 --> 00:19:48,240
much higher resolution

518
00:19:52,070 --> 00:19:50,080
um there's another reason why uh

519
00:19:55,350 --> 00:19:52,080
sonification can be a benefit and it

520
00:19:56,310 --> 00:19:55,360
gives you a another way of analyzing

521
00:19:59,750 --> 00:19:56,320
data besides

522
00:20:01,669 --> 00:19:59,760
visually so in particular

523
00:20:03,909 --> 00:20:01,679
sonifying data allows us to do what we

524
00:20:06,230 --> 00:20:03,919
call multi-dimensional analysis

525
00:20:08,310 --> 00:20:06,240
or multi-dimensional um you know sort of

526
00:20:09,750 --> 00:20:08,320
uh preview of the data

527
00:20:10,950 --> 00:20:09,760
and what i mean by multiple dimensions

528
00:20:12,390 --> 00:20:10,960
i'll go through real quick with some

529
00:20:16,149 --> 00:20:12,400
examples so

530
00:20:19,110 --> 00:20:16,159
if i asked you to make a chart

531
00:20:20,549 --> 00:20:19,120
of a baby and how it's growing in uh in

532
00:20:22,470 --> 00:20:20,559
its weight over time

533
00:20:24,070 --> 00:20:22,480
you can do that you could measure the

534
00:20:25,750 --> 00:20:24,080
weight and make a

535
00:20:27,909 --> 00:20:25,760
chart you probably have seen these in

536
00:20:28,789 --> 00:20:27,919
doctor's offices some of you may even do

537
00:20:30,710 --> 00:20:28,799
this at home

538
00:20:33,190 --> 00:20:30,720

it's not not too hard to do we have you

539
00:20:34,950 --> 00:20:33,200
know the age on the horizontal axis we

540
00:20:36,070 --> 00:20:34,960
have the weight on the vertical axis not

541
00:20:38,630 --> 00:20:36,080
a problem

542
00:20:39,909 --> 00:20:38,640
now if i ask you though to go ahead and

543
00:20:43,029 --> 00:20:39,919
try and do that

544
00:20:44,149 --> 00:20:43,039
and i want to see how the weight and the

545
00:20:47,430 --> 00:20:44,159
height

546
00:20:48,950 --> 00:20:47,440
sort of correlate with age now we have

547
00:20:50,149 --> 00:20:48,960
to make a three-dimensional plot and

548
00:20:52,149 --> 00:20:50,159
that's a little harder to do

549
00:20:53,909 --> 00:20:52,159
but with computer graphics we're able to

550
00:20:56,070 --> 00:20:53,919
do that

551
00:20:56,950 --> 00:20:56,080
but if i then go ahead and ask you to

552
00:20:59,110 --> 00:20:56,960
now

553
00:21:01,029 --> 00:20:59,120
see how the weight and the height and

554
00:21:03,110 --> 00:21:01,039
the temperature and the o2 level and

555
00:21:04,230 --> 00:21:03,120
your vitamin d's and your blood pressure

556
00:21:07,029 --> 00:21:04,240
and all these things

557
00:21:08,710 --> 00:21:07,039
are all correlated together we run out

558
00:21:10,630 --> 00:21:08,720
of options right

559
00:21:12,230 --> 00:21:10,640
because we can only visualize a

560
00:21:15,110 --> 00:21:12,240
three-dimensional space

561
00:21:16,230 --> 00:21:15,120
on a 2d surface like a screen or a piece

562
00:21:18,390 --> 00:21:16,240
of paper

563
00:21:19,430 --> 00:21:18,400

so there are tricks you can try to do

564
00:21:21,590 --> 00:21:19,440
where you represent

565
00:21:24,070 --> 00:21:21,600
all these different variables using

566
00:21:25,990 --> 00:21:24,080
different visual cues like different

567
00:21:29,029 --> 00:21:26,000
colors for one thing and different

568
00:21:30,789 --> 00:21:29,039
sizes for another thing and different

569
00:21:33,270 --> 00:21:30,799
you know whether it's filled in or not

570
00:21:35,990 --> 00:21:33,280
and you play with the x and y and the z

571
00:21:36,789 --> 00:21:36,000
axes and but pretty quickly the chart

572
00:21:39,750 --> 00:21:36,799
becomes

573
00:21:41,510 --> 00:21:39,760
too complicated to see a lot of detail

574
00:21:43,430 --> 00:21:41,520
one of the cool things about sound is

575
00:21:46,149 --> 00:21:43,440
that it's inherently multi-dimensional

576
00:21:48,950 --> 00:21:46,159
and if anybody has played around with 3d

577
00:21:50,310 --> 00:21:48,960
sound or have surround sound systems

578
00:21:53,510 --> 00:21:50,320
you kind of know this pretty well

579
00:21:56,230 --> 00:21:53,520
because you have not only the concept of

580
00:21:57,029 --> 00:21:56,240
if you have good speakers left and right

581
00:21:59,510 --> 00:21:57,039
up and down

582
00:22:01,430 --> 00:21:59,520
front and back but also things like the

583
00:22:03,590 --> 00:22:01,440
volume of the sound can be changed and

584
00:22:05,350 --> 00:22:03,600
the type of sound itself can be changed

585
00:22:06,789 --> 00:22:05,360
whether it's different instruments or

586
00:22:08,470 --> 00:22:06,799
you can change different pitches and

587
00:22:10,710 --> 00:22:08,480
different tones and overtones

588
00:22:12,149 --> 00:22:10,720

and we immediately have all these extra

589
00:22:13,990 --> 00:22:12,159
things to be able to

590
00:22:15,590 --> 00:22:14,000
assign to variables to be able to

591
00:22:17,029 --> 00:22:15,600
explore a data set from an audio

592
00:22:19,350 --> 00:22:17,039
perspective

593
00:22:21,110 --> 00:22:19,360
and the third and most important reason

594
00:22:23,029 --> 00:22:21,120
is accessibility

595
00:22:24,470 --> 00:22:23,039
so for people who are blind or low

596
00:22:26,710 --> 00:22:24,480
vision

597
00:22:28,549 --> 00:22:26,720
the only way that they can really um you

598
00:22:30,549 --> 00:22:28,559
know interact with data is primarily

599
00:22:33,270 --> 00:22:30,559
through audio or touch

600
00:22:35,350 --> 00:22:33,280
and astronomy in particular as well as

601
00:22:36,630 --> 00:22:35,360
science in general is oftentimes such a

602
00:22:42,470 --> 00:22:36,640
visual

603
00:22:44,470 --> 00:22:42,480
um where you know images and and uh

604
00:22:47,590 --> 00:22:44,480
graphs and all these things are

605
00:22:51,029 --> 00:22:47,600
are dominant in in in our field and so

606
00:22:53,350 --> 00:22:51,039
providing data through a sonified format

607
00:22:54,470 --> 00:22:53,360
um increases the accessibility of data

608
00:22:56,630 --> 00:22:54,480
to these um

609
00:22:58,230 --> 00:22:56,640
to the to community scientists who are

610
00:23:00,310 --> 00:22:58,240
interested in participating

611
00:23:02,470 --> 00:23:00,320
in in things like citizen science

612
00:23:05,830 --> 00:23:02,480
projects and also for those who want to

613
00:23:08,710 --> 00:23:05,840

do astronomy as a career so

614
00:23:09,590 --> 00:23:08,720
um those are our motivations uh for the

615
00:23:11,669 --> 00:23:09,600
project

616
00:23:13,430 --> 00:23:11,679
and i'm going to take you through a

617
00:23:15,190 --> 00:23:13,440
couple simple examples

618
00:23:16,789 --> 00:23:15,200
uh using shapes because shapes are

619
00:23:18,789 --> 00:23:16,799
something we all understand and then i'm

620
00:23:21,190 --> 00:23:18,799
going to pass it off to claire who

621
00:23:21,990 --> 00:23:21,200
get into this astrophysics part so this

622
00:23:23,430 --> 00:23:22,000
is sort of to

623
00:23:25,510 --> 00:23:23,440
calibrate our understanding of what we

624
00:23:27,830 --> 00:23:25,520
mean by sonification and as a quick note

625
00:23:29,350 --> 00:23:27,840
because of the video and audio lag there

626
00:23:30,630 --> 00:23:29,360
might be a little bit of a difference

627
00:23:32,390 --> 00:23:30,640
between the sound you're hearing and

628
00:23:33,350 --> 00:23:32,400
where the red marker is but don't worry

629
00:23:34,789 --> 00:23:33,360
about it

630
00:23:37,029 --> 00:23:34,799
if you're curious you can always go to

631
00:23:37,830 --> 00:23:37,039
our home page and click on the youtube

632
00:23:40,230 --> 00:23:37,840
videos

633
00:23:41,350 --> 00:23:40,240
for for some of these and and get a good

634
00:23:43,510 --> 00:23:41,360
sync but

635
00:23:44,950 --> 00:23:43,520
we'll continue so to get everybody on

636
00:23:45,990 --> 00:23:44,960
the zero point what i'm going to play

637
00:23:48,870 --> 00:23:46,000
right now

638
00:23:49,590 --> 00:23:48,880

is the simplest possible use case which

639
00:23:58,630 --> 00:23:49,600
is

640
00:24:02,070 --> 00:24:01,269
constant steady tone because we have

641
00:24:04,789 --> 00:24:02,080
constant

642
00:24:05,909 --> 00:24:04,799
steady shape okay that's pretty pretty

643
00:24:07,590 --> 00:24:05,919
good to understand

644
00:24:09,350 --> 00:24:07,600
let's change it a little bit now and

645
00:24:10,070 --> 00:24:09,360
what we're going to do is we're going to

646
00:24:13,669 --> 00:24:10,080
draw

647
00:24:14,630 --> 00:24:13,679
a diagonal straight line roughly at a 45

648
00:24:16,470 --> 00:24:14,640
degree angle

649
00:24:18,480 --> 00:24:16,480
and we'll see what happens when we

650
00:24:25,110 --> 00:24:18,490
solidify the shape

651
00:24:28,630 --> 00:24:27,190
all right so now you can really hear

652
00:24:30,630 --> 00:24:28,640
that things are changing

653
00:24:32,149 --> 00:24:30,640
this just like the line or the shape

654
00:24:34,230 --> 00:24:32,159
itself is changing the

655
00:24:35,669 --> 00:24:34,240
the sound you're hearing in pitch is

656
00:24:37,990 --> 00:24:35,679
going from low and

657
00:24:39,669 --> 00:24:38,000
constantly going up to a higher and

658
00:24:41,190 --> 00:24:39,679
higher pitch at the end

659
00:24:43,110 --> 00:24:41,200
now let's look at what we might expect

660
00:24:44,789 --> 00:24:43,120
for the top of a triangle

661
00:24:46,230 --> 00:24:44,799
and i bet you you all can figure out

662
00:24:48,340 --> 00:24:46,240
what might what this might sound like

663
00:24:54,310 --> 00:24:48,350

let's go ahead and listen to this too

664
00:24:57,350 --> 00:24:56,870
all right so that sounds just like we

665
00:24:59,350 --> 00:24:57,360
might

666
00:25:01,190 --> 00:24:59,360
expect it based on either the shape or

667
00:25:03,669 --> 00:25:01,200
or the graph

668
00:25:05,590 --> 00:25:03,679
we have essentially two diagonal lines

669
00:25:07,590 --> 00:25:05,600
one going up one going down and

670
00:25:10,070 --> 00:25:07,600
just like the shape itself the sound is

671
00:25:12,549 --> 00:25:10,080
literally rising and falling

672
00:25:14,149 --> 00:25:12,559
constantly and pretty sharp so the very

673
00:25:15,830 --> 00:25:14,159
last thing i want to present

674
00:25:18,350 --> 00:25:15,840
is what the top of a circle might sound

675
00:25:24,310 --> 00:25:18,360
like let's go ahead and listen to that

676
00:25:27,430 --> 00:25:24,320
[Music]

677
00:25:28,149 --> 00:25:27,440
so just like the triangle and just like

678
00:25:30,710 --> 00:25:28,159
the shape

679
00:25:32,549 --> 00:25:30,720
the circle is also rising and falling

680
00:25:34,230 --> 00:25:32,559
but the shape itself if you think about

681
00:25:36,789 --> 00:25:34,240
a triangle compared to a circle

682
00:25:37,350 --> 00:25:36,799
it's a much more gradual and constant

683
00:25:41,430 --> 00:25:37,360
change

684
00:25:43,350 --> 00:25:41,440
one side of the circle to the top

685
00:25:45,430 --> 00:25:43,360
and to the other side of the circle and

686
00:25:48,230 --> 00:25:45,440
just like that you should have heard

687
00:25:49,350 --> 00:25:48,240
the sound compared to the triangle also

688
00:25:51,269 --> 00:25:49,360

change in pitch

689
00:25:53,909 --> 00:25:51,279
much more gradually until it reached the

690
00:25:56,070 --> 00:25:53,919
top and then gradually fall down

691
00:25:58,230 --> 00:25:56,080
as opposed to a triangle which had much

692
00:26:00,070 --> 00:25:58,240
quicker changes in pitch when it

693
00:26:01,510 --> 00:26:00,080
got to the top and then went back down

694
00:26:03,350 --> 00:26:01,520
again so

695
00:26:05,909 --> 00:26:03,360
this is just to show you what we mean by

696
00:26:06,870 --> 00:26:05,919
sonifying data in this case it's shapes

697
00:26:08,950 --> 00:26:06,880
but for the next part of the

698
00:26:09,669 --> 00:26:08,960
presentation clara is going to go

699
00:26:11,269 --> 00:26:09,679
through

700
00:26:13,110 --> 00:26:11,279
some examples of how we take

701
00:26:13,909 --> 00:26:13,120
astronomical data this is real

702
00:26:17,430 --> 00:26:13,919
measurements

703
00:26:20,230 --> 00:26:17,440
brightness of objects

704
00:26:21,269 --> 00:26:20,240
and will translate those measurements

705
00:26:25,269 --> 00:26:21,279
into sound

706
00:26:27,510 --> 00:26:25,279
claire over to you

707
00:26:29,669 --> 00:26:27,520
hi everyone um so i'm going to talk

708
00:26:31,510 --> 00:26:29,679
about as scott said

709
00:26:33,110 --> 00:26:31,520
applying the techniques that we use to

710
00:26:34,870 --> 00:26:33,120
sonify those simple

711
00:26:37,269 --> 00:26:34,880
shapes and applying that to real

712
00:26:41,190 --> 00:26:37,279
astronomical data

713
00:26:43,110 --> 00:26:41,200

whoops so to start off with

714
00:26:44,230 --> 00:26:43,120
the kind of data that we're sonifying is

715
00:26:46,789 --> 00:26:44,240
called a light curve

716
00:26:48,230 --> 00:26:46,799
so the very introduction um there were

717
00:26:51,029 --> 00:26:48,240
all these beautiful pictures

718
00:26:52,230 --> 00:26:51,039
of galaxies and stars and even a

719
00:26:54,710 --> 00:26:52,240
birthday cake

720
00:26:56,230 --> 00:26:54,720
and there and those are all images this

721
00:26:58,390 --> 00:26:56,240
is a different kind of data

722
00:27:01,190 --> 00:26:58,400
it's fundamentally a record of how

723
00:27:03,430 --> 00:27:01,200
bright an object is a star or a galaxy

724
00:27:04,710 --> 00:27:03,440
or whatever astronomical object we're

725
00:27:08,390 --> 00:27:04,720
looking at is

726
00:27:12,470 --> 00:27:08,400
over time space telescope

727
00:27:14,470 --> 00:27:12,480
holds uh data from two very important

728
00:27:16,070 --> 00:27:14,480
space telescope missions that produce

729
00:27:18,230 --> 00:27:16,080
light curves they're tess

730
00:27:20,870 --> 00:27:18,240
and kepler and both of them their

731
00:27:23,830 --> 00:27:20,880
primary purpose has been

732
00:27:25,830 --> 00:27:23,840
to search for exoplanets planets that

733
00:27:29,029 --> 00:27:25,840
orbit stars other than the sun

734
00:27:31,750 --> 00:27:29,039
however they both produce a lot of

735
00:27:33,990 --> 00:27:31,760
data about a lot of stars and so we can

736
00:27:35,750 --> 00:27:34,000
use that data to look at a lot of

737
00:27:38,789 --> 00:27:35,760
different astrophysical phenomena

738
00:27:41,269 --> 00:27:38,799

not just exoplanets

739
00:27:42,149 --> 00:27:41,279
so the way we typically visualize light

740
00:27:46,230 --> 00:27:42,159
curves

741
00:27:48,310 --> 00:27:46,240
is as a line graph because it is

742
00:27:49,430 --> 00:27:48,320
a measure of the brightness of star over

743
00:27:51,510 --> 00:27:49,440
time we

744
00:27:53,990 --> 00:27:51,520
you you really what you have is a data

745
00:27:56,870 --> 00:27:54,000
table that has two columns one is time

746
00:27:59,669 --> 00:27:56,880
and one is how bright the star is so we

747
00:28:02,149 --> 00:27:59,679
can plot that with time on the x-axis

748
00:28:03,430 --> 00:28:02,159
and light on the y-axis and then we can

749
00:28:05,990 --> 00:28:03,440
just look at

750
00:28:07,909 --> 00:28:06,000
the line and see when it's higher the

751
00:28:11,430 --> 00:28:07,919
star is brighter and when it's dimmer

752
00:28:13,830 --> 00:28:11,440
the when it's lower the star is dimmer

753
00:28:16,710 --> 00:28:13,840
so when we translate that into sound we

754
00:28:18,470 --> 00:28:16,720
keep time as time we simply scale it to

755
00:28:19,350 --> 00:28:18,480
be something that's reasonable to listen

756
00:28:21,350 --> 00:28:19,360
to

757
00:28:22,630 --> 00:28:21,360
and then instead of translating how

758
00:28:26,549 --> 00:28:22,640
bright the star is

759
00:28:27,750 --> 00:28:26,559
into the place on the plot we translate

760
00:28:29,830 --> 00:28:27,760
it into the pitch

761
00:28:31,590 --> 00:28:29,840
so just like scott showed the higher the

762
00:28:32,710 --> 00:28:31,600
pitch the more light and the lower they

763
00:28:35,830 --> 00:28:32,720

picked the less light

764
00:28:38,470 --> 00:28:35,840
so this is a real piece of data from

765
00:28:39,590 --> 00:28:38,480
one star that came from the kepler light

766
00:28:41,669 --> 00:28:39,600
curve

767
00:28:44,770 --> 00:28:41,679
kepler space telescope and this is how

768
00:28:50,480 --> 00:28:44,780
it sounds

769
00:28:54,230 --> 00:28:50,490
[Music]

770
00:28:58,230 --> 00:28:54,240
[Laughter]

771
00:29:02,389 --> 00:28:58,240
so this is pretty similar

772
00:29:03,830 --> 00:29:02,399
to to what scott was showing but it's a

773
00:29:05,430 --> 00:29:03,840
little more complicated because this

774
00:29:06,630 --> 00:29:05,440
isn't a simple shape this is the light

775
00:29:09,590 --> 00:29:06,640
from a star

776
00:29:11,350 --> 00:29:09,600
um so we can use this then to look at a

777
00:29:13,750 --> 00:29:11,360
lot of different things

778
00:29:14,870 --> 00:29:13,760
so even though i said that we can look

779
00:29:16,389 --> 00:29:14,880
at a lot of different things we're going

780
00:29:17,590 --> 00:29:16,399
to start with exoplanets because

781
00:29:21,029 --> 00:29:17,600
exoplanets

782
00:29:22,789 --> 00:29:21,039
these telescopes

783
00:29:24,470 --> 00:29:22,799
were put into orbit and the reason that

784
00:29:27,909 --> 00:29:24,480
they were designed to

785
00:29:28,470 --> 00:29:27,919
return light curves so when you're

786
00:29:31,510 --> 00:29:28,480
looking

787
00:29:32,950 --> 00:29:31,520
for exoplanets in light curves what

788
00:29:36,389 --> 00:29:32,960

you're looking for

789
00:29:38,149 --> 00:29:36,399
is what we call a transit which is when

790
00:29:40,470 --> 00:29:38,159
a planet

791
00:29:41,909 --> 00:29:40,480
crosses between the viewer in this case

792
00:29:44,310 --> 00:29:41,919
officer the telescope

793
00:29:46,630 --> 00:29:44,320
and the star that it's orbiting so the

794
00:29:48,789 --> 00:29:46,640
star is putting out an amount of light

795
00:29:49,669 --> 00:29:48,799
and then some of that light is blocked

796
00:29:52,149 --> 00:29:49,679
as the

797
00:29:53,669 --> 00:29:52,159
planet transits across it and then when

798
00:29:55,830 --> 00:29:53,679
it finishes translating across

799
00:29:57,510 --> 00:29:55,840
and continues its orbit around the back

800
00:29:58,630 --> 00:29:57,520
the light from the star is not blocked

801
00:29:59,590 --> 00:29:58,640
again

802
00:30:01,510 --> 00:29:59,600
so we're looking for these

803
00:30:04,070 --> 00:30:01,520
characteristic dips in the light curve

804
00:30:06,870 --> 00:30:04,080
that occur at regular intervals

805
00:30:09,510 --> 00:30:06,880
as the star continues around and around

806
00:30:11,990 --> 00:30:09,520
its planet

807
00:30:13,029 --> 00:30:12,000
so we've discovered that there are a lot

808
00:30:15,430 --> 00:30:13,039
of planets

809
00:30:17,430 --> 00:30:15,440
outside of our own solar system just a

810
00:30:19,669 --> 00:30:17,440
lot of all different kinds

811
00:30:21,269 --> 00:30:19,679
and many that are just very very foreign

812
00:30:23,590 --> 00:30:21,279
to anything that we have

813
00:30:25,190 --> 00:30:23,600

in our solar system and one of the ones

814
00:30:27,590 --> 00:30:25,200
that i think is particularly interesting

815
00:30:29,350 --> 00:30:27,600
are what are called hot jupiters

816
00:30:31,510 --> 00:30:29,360
so probably some of you have guessed

817
00:30:34,230 --> 00:30:31,520
that these are jupiter-sized planets

818
00:30:35,430 --> 00:30:34,240
but unlike our jupiter with orbits

819
00:30:37,110 --> 00:30:35,440
pretty far out

820
00:30:39,830 --> 00:30:37,120
from its sun certainly farther out than

821
00:30:42,549 --> 00:30:39,840
we on earth do hot jupiters orbit

822
00:30:43,190 --> 00:30:42,559
incredibly close to their host star like

823
00:30:44,870 --> 00:30:43,200
closer

824
00:30:46,630 --> 00:30:44,880
than the orbit of mercury if they were

825
00:30:49,990 --> 00:30:46,640
in our solar system

826
00:30:53,669 --> 00:30:50,000
and jupiter our jupiter is made up of

827
00:30:55,350 --> 00:30:53,679
a lot of gas and so these jupiters are

828
00:30:57,990 --> 00:30:55,360
are like that too their composition is

829
00:31:00,870 --> 00:30:58,000
more like jupiter so they're just huge

830
00:31:03,190 --> 00:31:00,880
and puffy and hot and very very close to

831
00:31:06,230 --> 00:31:03,200
their host star

832
00:31:08,149 --> 00:31:06,240
so kepler-12b um is a planet that was

833
00:31:09,269 --> 00:31:08,159
observed unsurprisingly by the kepler

834
00:31:11,190 --> 00:31:09,279
space telescope

835
00:31:13,029 --> 00:31:11,200
and it's a hot jupiter that is orbiting

836
00:31:14,310 --> 00:31:13,039
a star that is very similar to our own

837
00:31:16,230 --> 00:31:14,320
sun

838
00:31:17,990 --> 00:31:16,240

but obviously its system is very

839
00:31:19,990 --> 00:31:18,000
different from ours it has a period of

840
00:31:20,549 --> 00:31:20,000
just four and a half days so that means

841
00:31:23,269 --> 00:31:20,559
the

842
00:31:25,509 --> 00:31:23,279
equivalent of a year on this planet is

843
00:31:27,190 --> 00:31:25,519
just four and a half days

844
00:31:29,190 --> 00:31:27,200
and knowing that we can also get a sense

845
00:31:29,990 --> 00:31:29,200
of the time scale of this sonification

846
00:31:35,669 --> 00:31:30,000
here

847
00:31:36,149 --> 00:31:35,679
this flat flattish line across the top

848
00:31:40,950 --> 00:31:36,159
is

849
00:31:43,830 --> 00:31:40,960
in these dips

850
00:31:45,669 --> 00:31:43,840
by the transiting exoplanet and so the

851
00:31:48,149 --> 00:31:45,679
distance between these

852
00:31:51,509 --> 00:31:48,159
is going to be the length of the orbit

853
00:31:54,070 --> 00:31:51,519
of this planet so this is 4.5 days

854
00:31:55,029 --> 00:31:54,080
so we've sped it up so that it will

855
00:31:57,430 --> 00:31:55,039
actually play

856
00:31:59,029 --> 00:31:57,440
in just a couple of seconds but that

857
00:32:12,230 --> 00:31:59,039
gives us a sense of scale

858
00:32:16,070 --> 00:32:14,870
so we can hear this constant pitch that

859
00:32:19,110 --> 00:32:16,080
is the light from the sun

860
00:32:21,830 --> 00:32:19,120
interrupted by these lower

861
00:32:23,830 --> 00:32:21,840
cords that are the transit of the planet

862
00:32:26,789 --> 00:32:23,840
periodically

863
00:32:27,430 --> 00:32:26,799

and this and this planet but because it

864
00:32:29,669 --> 00:32:27,440
is so

865
00:32:31,269 --> 00:32:29,679
big and so close it blocks out a lot of

866
00:32:34,630 --> 00:32:31,279
the light from its star so these dips

867
00:32:38,630 --> 00:32:36,470
the second type of star i'm going to

868
00:32:40,389 --> 00:32:38,640
talk about is called a heartbeat star

869
00:32:42,310 --> 00:32:40,399
and it's it's called a heartbeat star

870
00:32:45,590 --> 00:32:42,320
but it's actually a binary star

871
00:32:47,830 --> 00:32:45,600
system and it consists of one star

872
00:32:49,830 --> 00:32:47,840
orbiting a larger star in an elliptical

873
00:32:52,070 --> 00:32:49,840
orbit and so what that means

874
00:32:52,950 --> 00:32:52,080
is that there's a large star and a

875
00:32:54,149 --> 00:32:52,960
smaller star

876
00:32:56,630 --> 00:32:54,159
is orbiting in such a way where

877
00:32:58,789 --> 00:32:56,640
sometimes it's very close to that

878
00:33:00,070 --> 00:32:58,799
large star and sometimes it's very far

879
00:33:02,950 --> 00:33:00,080
away

880
00:33:03,590 --> 00:33:02,960
and what what the result of this is the

881
00:33:07,269 --> 00:33:03,600
while

882
00:33:08,950 --> 00:33:07,279
the smaller star is is much smaller

883
00:33:11,590 --> 00:33:08,960
it isn't as small as a planet and it

884
00:33:13,830 --> 00:33:11,600
still exerts quite a

885
00:33:15,110 --> 00:33:13,840
it exerts a gravitational pull on the

886
00:33:17,350 --> 00:33:15,120
larger star

887
00:33:19,190 --> 00:33:17,360
enough to destabilize the star and

888
00:33:21,190 --> 00:33:19,200

essentially cause it to ring like a bell

889
00:33:22,310 --> 00:33:21,200
so there's these ongoing vibrations in

890
00:33:24,070 --> 00:33:22,320
the larger star

891
00:33:25,669 --> 00:33:24,080
and they are stronger when the stars are

892
00:33:27,750 --> 00:33:25,679
closer together and

893
00:33:28,870 --> 00:33:27,760
weaker when the stars are farther away

894
00:33:31,110 --> 00:33:28,880
and the result of this

895
00:33:33,750 --> 00:33:31,120
is that the light curve when plotted

896
00:33:36,310 --> 00:33:33,760
looks a little bit like an ekg

897
00:33:38,070 --> 00:33:36,320
with the up and down um and so this is

898
00:33:40,950 --> 00:33:38,080
why it got the name heartbeat star

899
00:33:42,230 --> 00:33:40,960
even though it's actually two stars and

900
00:33:44,630 --> 00:33:42,240
so this is the plot

901
00:33:46,230 --> 00:33:44,640
and we can see that behavior these these

902
00:33:47,990 --> 00:33:46,240
are the the

903
00:33:49,430 --> 00:33:48,000
the small up and downs that are the

904
00:33:51,269 --> 00:33:49,440
vibrations

905
00:33:53,590 --> 00:33:51,279
that are induced in the large star and

906
00:33:55,350 --> 00:33:53,600
they get larger and smaller and larger

907
00:33:57,909 --> 00:33:55,360
and smaller on a fixed

908
00:33:59,029 --> 00:33:57,919
on a fixed period and that is the orbit

909
00:34:02,230 --> 00:33:59,039
of the star

910
00:34:04,310 --> 00:34:02,240
and so if we solidify this um such

911
00:34:05,990 --> 00:34:04,320
such that we're scanning across it very

912
00:34:09,030 --> 00:34:06,000
quickly we can hear that large

913
00:34:13,589 --> 00:34:09,040

scale orbiting pattern very easily

914
00:34:18,149 --> 00:34:15,990
so here it does really feel in some ways

915
00:34:21,109 --> 00:34:18,159
like a beading pattern so you can sort

916
00:34:24,149 --> 00:34:21,119
of feel that heartbeat

917
00:34:26,069 --> 00:34:24,159
but you can't really distinguish the

918
00:34:27,829 --> 00:34:26,079
smaller scale changes you just know that

919
00:34:29,510 --> 00:34:27,839
you're getting a large chord and then

920
00:34:31,430 --> 00:34:29,520
just a few notes and then a large chord

921
00:34:31,990 --> 00:34:31,440
so you can hear that but you can't hear

922
00:34:35,430 --> 00:34:32,000
the

923
00:34:37,990 --> 00:34:35,440
again but this time

924
00:34:50,790 --> 00:34:38,000
scan across much slower we can start to

925
00:34:55,909 --> 00:34:53,750
so now it's a little bit harder to

926
00:34:57,910 --> 00:34:55,919
detect the larger scale pattern because

927
00:34:59,670 --> 00:34:57,920
it's so much slower but we can really

928
00:35:01,589 --> 00:34:59,680
hear those vibrations

929
00:35:02,710 --> 00:35:01,599
and so the way you sonify a piece of

930
00:35:04,550 --> 00:35:02,720
data just like

931
00:35:06,790 --> 00:35:04,560
you make changes in how you visualize a

932
00:35:08,470 --> 00:35:06,800
piece of data is based on

933
00:35:10,470 --> 00:35:08,480
what you're trying to explore what

934
00:35:15,990 --> 00:35:10,480
features you're looking for

935
00:35:17,589 --> 00:35:16,000
and what information you want to get out

936
00:35:19,589 --> 00:35:17,599
so the next type of star we're going to

937
00:35:21,589 --> 00:35:19,599
look at is a pulsating star and so this

938
00:35:22,550 --> 00:35:21,599

is a single star and it's a next star

939
00:35:25,270 --> 00:35:22,560
that expands

940
00:35:26,710 --> 00:35:25,280
and contracts regularly these stars tend

941
00:35:30,550 --> 00:35:26,720
to be very hot

942
00:35:33,589 --> 00:35:30,560
um they are unstable um so

943
00:35:34,550 --> 00:35:33,599
inside the star in with all of the hot

944
00:35:36,470 --> 00:35:34,560
plasma

945
00:35:38,069 --> 00:35:36,480
there's some instabilities so so that

946
00:35:39,910 --> 00:35:38,079
the star will puff off it will get

947
00:35:42,550 --> 00:35:39,920
hotter and puff up

948
00:35:43,990 --> 00:35:42,560
and then it won't be able to sustain

949
00:35:45,349 --> 00:35:44,000
itself and so

950
00:35:46,950 --> 00:35:45,359
gravity will start to take over and

951
00:35:47,990 --> 00:35:46,960
it'll collapse back and at a certain

952
00:35:51,109 --> 00:35:48,000
point

953
00:35:53,670 --> 00:35:51,119
the the compression of the plasma

954
00:35:54,310 --> 00:35:53,680
will will cause it to stop and heat and

955
00:35:56,150 --> 00:35:54,320
heat up more

956
00:35:57,670 --> 00:35:56,160
and expand again and this just goes back

957
00:35:59,510 --> 00:35:57,680
and forth and back and forth

958
00:36:01,589 --> 00:35:59,520
and so you have this in and out motion

959
00:36:04,390 --> 00:36:01,599
and that

960
00:36:05,109 --> 00:36:04,400
and and so that physical motion of the

961
00:36:07,270 --> 00:36:05,119
star

962
00:36:08,470 --> 00:36:07,280
translates to a corresponding change in

963
00:36:12,310 --> 00:36:08,480

the brightness

964
00:36:12,630 --> 00:36:12,320
um that so in this case when we solidify

965
00:36:15,430 --> 00:36:12,640
it

966
00:36:16,470 --> 00:36:15,440
we're sort of inferring from an infer so

967
00:36:19,190 --> 00:36:16,480
we're we're using

968
00:36:21,270 --> 00:36:19,200
sound to hear the differences in light

969
00:36:21,589 --> 00:36:21,280
which is telling us about the changes in

970
00:36:27,670 --> 00:36:21,599
the

971
00:36:28,470 --> 00:36:27,680
happen over short periods of a couple

972
00:36:31,670 --> 00:36:28,480
two

973
00:36:34,390 --> 00:36:31,680
days to maybe a little over a week

974
00:36:36,150 --> 00:36:34,400
and they're very regular so this is a

975
00:36:38,069 --> 00:36:36,160
heartbeat star this is what's called a

976
00:36:40,790 --> 00:36:38,079
delta scooty so it's a young

977
00:36:42,950 --> 00:36:40,800
hot pulsating star so it's very young

978
00:36:53,589 --> 00:36:42,960
and it's very hot and it's wobbling

979
00:36:59,270 --> 00:36:56,950
and it just keeps going we have

980
00:37:00,550 --> 00:36:59,280
years of this data and it just keeps

981
00:37:02,950 --> 00:37:00,560
going because on

982
00:37:05,109 --> 00:37:02,960
on the scale at which we're taking data

983
00:37:09,670 --> 00:37:05,119
for these space telescopes

984
00:37:11,670 --> 00:37:09,680
um uh

985
00:37:13,829 --> 00:37:11,680
it is very constant even though it's an

986
00:37:15,109 --> 00:37:13,839
unstable star it's unstable in a very

987
00:37:18,310 --> 00:37:15,119
stable way

988
00:37:20,230 --> 00:37:18,320

it's it's it's um going out to the same

989
00:37:21,190 --> 00:37:20,240
radius and shrinking to the same radius

990
00:37:23,589 --> 00:37:21,200
and continuing

991
00:37:24,870 --> 00:37:23,599
but on astronomical scales these stars

992
00:37:28,710 --> 00:37:24,880
are unstable

993
00:37:30,710 --> 00:37:28,720
and so they're short-lived and and

994
00:37:32,470 --> 00:37:30,720
and are and are some of the more active

995
00:37:33,510 --> 00:37:32,480
stars in terms of moving around their

996
00:37:35,349 --> 00:37:33,520
characteristics

997
00:37:37,349 --> 00:37:35,359
but that's still on an astronomical

998
00:37:39,349 --> 00:37:37,359
scale so it's much longer than a scale

999
00:37:41,990 --> 00:37:39,359
that we can see over the course of even

1000
00:37:44,390 --> 00:37:42,000
a relatively long

1001
00:37:49,589 --> 00:37:44,400
telescope mission like kepler which took

1002
00:37:52,950 --> 00:37:51,349
uh and so the last astronomical

1003
00:37:54,710 --> 00:37:52,960
phenomena i'm going to talk about

1004
00:37:56,390 --> 00:37:54,720
is different than the ones i've talked

1005
00:37:58,790 --> 00:37:56,400
to all of the ones i've talked about

1006
00:38:02,390 --> 00:37:58,800
before that all have some sort of

1007
00:38:04,310 --> 00:38:02,400
regular uh period with what

1008
00:38:06,470 --> 00:38:04,320
whether it's because there's a planet

1009
00:38:07,109 --> 00:38:06,480
rotating a star a star rotating another

1010
00:38:15,829 --> 00:38:07,119
star

1011
00:38:18,950 --> 00:38:15,839
the stellar equivalent of solar flares

1012
00:38:19,829 --> 00:38:18,960
and they're a result of buildups of

1013
00:38:22,950 --> 00:38:19,839

energy

1014
00:38:25,430 --> 00:38:22,960
in the upper layers of the star and

1015
00:38:27,430 --> 00:38:25,440
the atmosphere and they build up slowly

1016
00:38:30,550 --> 00:38:27,440
over time and when a certain critical

1017
00:38:32,950 --> 00:38:30,560
amount of energy is is reached

1018
00:38:34,630 --> 00:38:32,960
it needs to go somewhere and so it

1019
00:38:36,870 --> 00:38:34,640
explodes

1020
00:38:37,829 --> 00:38:36,880
very quickly in a burst of light and

1021
00:38:40,870 --> 00:38:37,839
energy

1022
00:38:42,790 --> 00:38:40,880
and then collapses back into the

1023
00:38:44,630 --> 00:38:42,800
star as it was before the explosion and

1024
00:38:48,150 --> 00:38:44,640
these aren't predictable

1025
00:38:50,710 --> 00:38:48,160
um we have we know basically

1026
00:38:52,390 --> 00:38:50,720
how many we expect to see of what energy

1027
00:38:54,310 --> 00:38:52,400
over a long period of time but we don't

1028
00:38:55,349 --> 00:38:54,320
know what any individual one is going to

1029
00:38:57,109 --> 00:38:55,359
happen

1030
00:38:58,870 --> 00:38:57,119
so instead of seeing something periodic

1031
00:39:01,030 --> 00:38:58,880
we see something more like this

1032
00:39:02,310 --> 00:39:01,040
where you have this baseline starlight

1033
00:39:04,550 --> 00:39:02,320
and then there's this

1034
00:39:07,109 --> 00:39:04,560
sudden sharp peak that's the flare that

1035
00:39:09,190 --> 00:39:07,119
then more gradually returns back to that

1036
00:39:11,829 --> 00:39:09,200
baseline

1037
00:39:13,270 --> 00:39:11,839
and so here's a real flare from a space

1038
00:39:15,589 --> 00:39:13,280

telescope

1039
00:39:19,770 --> 00:39:15,599
and this is it sounds really quite

1040
00:39:25,190 --> 00:39:23,430
[Music]

1041
00:39:27,349 --> 00:39:25,200
so this is a great flare because you can

1042
00:39:28,950 --> 00:39:27,359
hear this sharp explosion

1043
00:39:31,109 --> 00:39:28,960
there's a sharp peak and then it and

1044
00:39:32,870 --> 00:39:31,119
then it gradually returns in fact at the

1045
00:39:34,470 --> 00:39:32,880
end of this set of data it has not

1046
00:39:38,390 --> 00:39:34,480
returned all the way back

1047
00:39:40,390 --> 00:39:38,400
um to the original uh original

1048
00:39:42,390 --> 00:39:40,400
amount of brightness so that will

1049
00:39:43,589 --> 00:39:42,400
continue if we had more data we'd get to

1050
00:39:46,550 --> 00:39:43,599
see it

1051
00:39:47,990 --> 00:39:46,560
however star uh flares occur at a lot of

1052
00:39:49,990 --> 00:39:48,000
different scales they can be

1053
00:39:51,349 --> 00:39:50,000
anything from a couple of minutes to a

1054
00:39:53,750 --> 00:39:51,359
couple of hours

1055
00:39:55,589 --> 00:39:53,760
in duration so depending on how often

1056
00:39:57,109 --> 00:39:55,599
we're taking measurements of the star

1057
00:39:59,270 --> 00:39:57,119
they could look like this one where we

1058
00:40:01,190 --> 00:39:59,280
get to really see the whole shape

1059
00:40:03,109 --> 00:40:01,200
or they could look more like this one

1060
00:40:05,190 --> 00:40:03,119
which is this large spike that just sort

1061
00:40:06,710 --> 00:40:05,200
of pops out and then disappears

1062
00:40:09,030 --> 00:40:06,720
because this flare is very short

1063
00:40:11,589 --> 00:40:09,040

compared to how often we are measuring

1064
00:40:12,309 --> 00:40:11,599
how bright the star is and so this light

1065
00:40:14,390 --> 00:40:12,319
curve

1066
00:40:15,829 --> 00:40:14,400
is also it it's got a lot of other

1067
00:40:17,829 --> 00:40:15,839
things going on there's some sort of

1068
00:40:19,990 --> 00:40:17,839
periodicity maybe there's some star

1069
00:40:20,630 --> 00:40:20,000
spots which are cooler parts of the star

1070
00:40:22,390 --> 00:40:20,640
that are

1071
00:40:24,790 --> 00:40:22,400
therefore dimmer and so when the star

1072
00:40:27,750 --> 00:40:24,800
rotates these cooler spots

1073
00:40:29,190 --> 00:40:27,760
will rotate with it and sometimes um

1074
00:40:30,150 --> 00:40:29,200
we're seeing them and sometimes we're

1075
00:40:32,790 --> 00:40:30,160
not so so

1076
00:40:33,750 --> 00:40:32,800
they have these small smaller scale

1077
00:40:36,710 --> 00:40:33,760
periodic

1078
00:40:37,829 --> 00:40:36,720
variations as we see the total amount of

1079
00:40:40,470 --> 00:40:37,839
brightness from the star

1080
00:40:42,470 --> 00:40:40,480
change based on the temperature in

1081
00:40:43,349 --> 00:40:42,480
various spots on the face of the star

1082
00:40:46,550 --> 00:40:43,359
we're seeing

1083
00:40:48,950 --> 00:40:46,560
and so that's happening um below these

1084
00:40:50,470 --> 00:40:48,960
this is definitely a flare this little

1085
00:40:52,069 --> 00:40:50,480
one might looks like it's probably a

1086
00:40:53,990 --> 00:40:52,079
flare and this one

1087
00:40:55,589 --> 00:40:54,000
even this one could be it's a little

1088
00:40:57,270 --> 00:40:55,599

hard to tell because this is a slightly

1089
00:41:00,840 --> 00:40:57,280
messier light curve

1090
00:41:00,850 --> 00:41:05,510
[Music]

1091
00:41:09,270 --> 00:41:07,270
so here it's a little harder to hear the

1092
00:41:09,670 --> 00:41:09,280
flares and they're just like little high

1093
00:41:11,589 --> 00:41:09,680
pitched

1094
00:41:12,950 --> 00:41:11,599
pitch blips that come out because

1095
00:41:14,710 --> 00:41:12,960
they're so fast

1096
00:41:16,390 --> 00:41:14,720
but we can see that they do stand out

1097
00:41:20,150 --> 00:41:16,400
above this general

1098
00:41:23,829 --> 00:41:20,160
um activity that's going on in the

1099
00:41:25,430 --> 00:41:23,839
non-flaring star and if we but if we did

1100
00:41:27,670 --> 00:41:25,440
want to really

1101
00:41:28,870 --> 00:41:27,680
dig into what's going on in the star

1102
00:41:30,630 --> 00:41:28,880
without flares well

1103
00:41:32,470 --> 00:41:30,640
we'd pick a part of the light curve

1104
00:41:34,470 --> 00:41:32,480
where there aren't any and then we would

1105
00:41:36,790 --> 00:41:34,480
do what i did with the heartbeat star

1106
00:41:40,710 --> 00:41:36,800
and slow it down and really zero in on

1107
00:41:46,470 --> 00:41:43,829
so that was a brief introduction to

1108
00:41:48,630 --> 00:41:46,480
various different kinds of astronomical

1109
00:41:50,870 --> 00:41:48,640
phenomena that we can sonify

1110
00:41:54,470 --> 00:41:50,880
and now i'm going to hand off to jen who

1111
00:41:59,190 --> 00:41:57,030
hello everyone welcome to the

1112
00:42:02,230 --> 00:41:59,200
astronomify game show

1113
00:42:03,270 --> 00:42:02,240

i'm your host jen cutler so we've now

1114
00:42:05,430 --> 00:42:03,280
arrived at the

1115
00:42:07,109 --> 00:42:05,440
interactive portion of this lecture

1116
00:42:08,790 --> 00:42:07,119
where we're all going to act as

1117
00:42:10,630 --> 00:42:08,800
astronomers working to discover

1118
00:42:14,230 --> 00:42:10,640
information about the universe

1119
00:42:15,670 --> 00:42:14,240
using our ears so in true game show

1120
00:42:16,710 --> 00:42:15,680
fashion we have several ways to

1121
00:42:18,950 --> 00:42:16,720
participate

1122
00:42:20,870 --> 00:42:18,960
of course the classic you can just shout

1123
00:42:23,670 --> 00:42:20,880
your answers at your screen

1124
00:42:25,270 --> 00:42:23,680
but when i say interactive i mean that i

1125
00:42:26,790 --> 00:42:25,280
want to hear from you

1126
00:42:28,870 --> 00:42:26,800
if you're watching this streaming live

1127
00:42:31,910 --> 00:42:28,880
on youtube uh till november 10th

1128
00:42:32,950 --> 00:42:31,920
2020 please find the chat and as we go

1129
00:42:34,710 --> 00:42:32,960
through each question

1130
00:42:36,870 --> 00:42:34,720
i want you to write what you think the

1131
00:42:38,550 --> 00:42:36,880
answer is and after each round

1132
00:42:39,990 --> 00:42:38,560
i'll check the chat to see how you're

1133
00:42:41,670 --> 00:42:40,000
all doing

1134
00:42:43,670 --> 00:42:41,680
if you're watching this after the

1135
00:42:44,309 --> 00:42:43,680
original stream there will be a link

1136
00:42:49,270 --> 00:42:44,319
added

1137
00:42:51,589 --> 00:42:49,280
on top of the video and also in the

1138
00:42:53,030 --> 00:42:51,599

description if you can follow along and

1139
00:42:53,750 --> 00:42:53,040
answer each of these questions in the

1140
00:42:55,510 --> 00:42:53,760
survey

1141
00:42:56,790 --> 00:42:55,520
as i go through them i would greatly

1142
00:42:59,430 --> 00:42:56,800
appreciate it

1143
00:43:00,550 --> 00:42:59,440
hearing back from you is um all

1144
00:43:03,030 --> 00:43:00,560
interacting with us

1145
00:43:03,910 --> 00:43:03,040
is really fun but it's also really

1146
00:43:07,510 --> 00:43:03,920
important

1147
00:43:09,190 --> 00:43:07,520
experience for our team

1148
00:43:10,870 --> 00:43:09,200
because it's a great way for us to check

1149
00:43:12,790 --> 00:43:10,880
in with a wide group of people

1150
00:43:13,990 --> 00:43:12,800
and see if these sonifications are

1151
00:43:15,829 --> 00:43:14,000
understandable

1152
00:43:18,150 --> 00:43:15,839
so it'll help us learn how to improve

1153
00:43:20,069 --> 00:43:18,160
our work thank you to everyone who

1154
00:43:23,430 --> 00:43:20,079
participates in advance

1155
00:43:25,589 --> 00:43:23,440
okay let's get started

1156
00:43:26,710 --> 00:43:25,599
so this game is going to have two rounds

1157
00:43:30,870 --> 00:43:26,720
round one is

1158
00:43:32,150 --> 00:43:30,880
flares so remember what clara said

1159
00:43:34,870 --> 00:43:32,160
earlier about flares

1160
00:43:36,230 --> 00:43:34,880
they are explosions on the surface of

1161
00:43:38,870 --> 00:43:36,240
stars

1162
00:43:40,630 --> 00:43:38,880
so first i'm going to show you an

1163
00:43:55,030 --> 00:43:40,640

idealized example

1164
00:43:57,990 --> 00:43:55,040
of what a flare sounds like sonified

1165
00:43:59,910 --> 00:43:58,000
so keep uh you know keep in mind that

1166
00:44:02,790 --> 00:43:59,920
short sudden rise and pitch

1167
00:44:04,390 --> 00:44:02,800
that uh has a slower decay at the end

1168
00:44:05,750 --> 00:44:04,400
that one was very ideal though and now

1169
00:44:06,829 --> 00:44:05,760
we're going to move on to real data

1170
00:44:08,069 --> 00:44:06,839
which might be a little bit more

1171
00:44:10,470 --> 00:44:08,079
difficult

1172
00:44:11,829 --> 00:44:10,480
so in this round i'm going to play four

1173
00:44:14,630 --> 00:44:11,839
sonifications

1174
00:44:16,550 --> 00:44:14,640
after each sonification i will ask you

1175
00:44:19,109 --> 00:44:16,560
did you hear a stellar flare

1176
00:44:20,069 --> 00:44:19,119
so if you're watching live please write

1177
00:44:22,069 --> 00:44:20,079
yes or no

1178
00:44:23,510 --> 00:44:22,079
in the chat and if you're not watching

1179
00:44:25,829 --> 00:44:23,520
live if you're watching later

1180
00:44:27,829 --> 00:44:25,839
can you please uh answer the question in

1181
00:44:30,069 --> 00:44:27,839
the poll as we go along

1182
00:44:30,950 --> 00:44:30,079
uh in the survey i mean link in the

1183
00:44:34,390 --> 00:44:30,960
description

1184
00:44:34,950 --> 00:44:34,400
okay so question one does this contain a

1185
00:44:39,280 --> 00:44:34,960
flare

1186
00:44:39,290 --> 00:44:47,670
[Music]

1187
00:44:51,589 --> 00:44:50,069
okay what do you all think let's uh take

1188
00:44:53,030 --> 00:44:51,599

a few seconds to

1189
00:44:55,030 --> 00:44:53,040
give you a chance to write it in the

1190
00:44:58,309 --> 00:44:55,040
chat answer on the survey

1191
00:45:00,069 --> 00:44:58,319
did you hear a flare what do you think

1192
00:45:03,589 --> 00:45:00,079
okay i think we've given enough time

1193
00:45:08,710 --> 00:45:06,950
yes that was a flare um

1194
00:45:10,710 --> 00:45:08,720
so you can see the arrow on the screen

1195
00:45:19,430 --> 00:45:10,720
and i'll also mention it as we pass it

1196
00:45:24,069 --> 00:45:19,440
uh in this replay

1197
00:45:30,470 --> 00:45:27,670
okay so great job everyone let's move on

1198
00:45:33,349 --> 00:45:30,480
to the next question

1199
00:45:49,670 --> 00:45:33,359
question two does this contain a flare

1200
00:45:53,829 --> 00:45:51,829
okay so let me give you a few seconds to

1201
00:45:56,790 --> 00:45:53,839
write in the chat or respond

1202
00:45:58,230 --> 00:45:56,800
in the survey yes or no did you hear a

1203
00:46:01,510 --> 00:45:58,240
flare there

1204
00:46:05,349 --> 00:46:01,520
there's certainly a lot of variation not

1205
00:46:08,470 --> 00:46:05,359
but was it a flare that's the question

1206
00:46:12,390 --> 00:46:08,480
let's see if anyone's responding yet

1207
00:46:16,470 --> 00:46:12,400
huh okay and let's

1208
00:46:21,990 --> 00:46:19,510
that one did not have a flare

1209
00:46:36,950 --> 00:46:22,000
so let's listen again just to not hear

1210
00:46:41,190 --> 00:46:40,390
okay so question three does this contain

1211
00:46:53,810 --> 00:46:41,200
a flare

1212
00:46:53,820 --> 00:47:00,309
[Music]

1213
00:47:04,870 --> 00:47:02,550

okay so are you listening closely what

1214
00:47:07,910 --> 00:47:04,880
did you hear was there a flare

1215
00:47:09,990 --> 00:47:07,920
what was going on with this one hmm

1216
00:47:11,990 --> 00:47:10,000
i'm wondering if anyone heard anything

1217
00:47:13,190 --> 00:47:12,000
unusual about this one

1218
00:47:15,670 --> 00:47:13,200
maybe they could comment if they think

1219
00:47:15,990 --> 00:47:15,680
it's different anything different about

1220
00:47:20,630 --> 00:47:16,000
this

1221
00:47:25,910 --> 00:47:23,670
okay but let's see

1222
00:47:26,950 --> 00:47:25,920
there was more than one flare not only

1223
00:47:30,790 --> 00:47:26,960
was there one

1224
00:47:32,230 --> 00:47:30,800
there was many flares great job everyone

1225
00:47:34,710 --> 00:47:32,240
for noticing that

1226
00:47:35,750 --> 00:47:34,720
so uh for question four we're going to

1227
00:47:37,670 --> 00:47:35,760
re-listen

1228
00:47:40,069 --> 00:47:37,680
to that previous modification and this

1229
00:47:42,390 --> 00:47:40,079
time i want you to count

1230
00:47:44,309 --> 00:47:42,400
how many flares you hear and this one is

1231
00:47:45,750 --> 00:47:44,319
a little tricky because some of them are

1232
00:47:47,750 --> 00:47:45,760
more subtle than others so you have to

1233
00:47:50,150 --> 00:47:47,760
listen really closely

1234
00:47:51,670 --> 00:47:50,160
okay so how many flares do you hear

1235
00:47:54,870 --> 00:47:51,680
write the number in the chat

1236
00:48:07,980 --> 00:47:54,880
or write the number in on the survey

1237
00:48:07,990 --> 00:48:15,510
[Music]

1238
00:48:20,950 --> 00:48:19,190

okay how many how many flares were there

1239
00:48:22,710 --> 00:48:20,960
so we know there's more than one but how

1240
00:48:25,430 --> 00:48:22,720
many exactly

1241
00:48:27,270 --> 00:48:25,440
let's see oh i see answers starting to

1242
00:48:30,790 --> 00:48:27,280
come in

1243
00:48:34,390 --> 00:48:30,800
okay give you another second to respond

1244
00:48:37,910 --> 00:48:34,400
in the chat

1245
00:48:40,470 --> 00:48:37,920
let's reveal the answer

1246
00:48:41,349 --> 00:48:40,480
there was seven flares and so i've

1247
00:48:43,270 --> 00:48:41,359
marked them off

1248
00:48:45,990 --> 00:48:43,280
so you can visually see them and then as

1249
00:48:51,750 --> 00:48:46,000
they pass along in the replay i'll also

1250
00:48:51,760 --> 00:48:55,990
one two

1251
00:49:05,670 --> 00:49:00,829
three four five

1252
00:49:09,270 --> 00:49:07,829
and so number six i think is the most

1253
00:49:11,430 --> 00:49:09,280
difficult to hear

1254
00:49:13,510 --> 00:49:11,440
uh you and you could see visually it is

1255
00:49:15,510 --> 00:49:13,520
the smallest out of all of them so you

1256
00:49:18,230 --> 00:49:15,520
have to be listening more closely to

1257
00:49:19,589 --> 00:49:18,240
find that one so i'm going to take a

1258
00:49:21,270 --> 00:49:19,599
moment to go back through the chat and

1259
00:49:23,190 --> 00:49:21,280
just see how everyone's doing because

1260
00:49:25,190 --> 00:49:23,200
it's a little bit delayed from what

1261
00:49:26,309 --> 00:49:25,200
i'm seeing i was seeing that everyone

1262
00:49:28,549 --> 00:49:26,319
i'm seeing a lot of

1263
00:49:30,069 --> 00:49:28,559

close answers a lot of seven some sixes

1264
00:49:31,829 --> 00:49:30,079
which i think is understandable on that

1265
00:49:34,870 --> 00:49:31,839
previous question

1266
00:49:38,230 --> 00:49:34,880
okay you all did see that there was

1267
00:49:39,990 --> 00:49:38,240
uh many flares that's awesome

1268
00:49:41,349 --> 00:49:40,000
you're all doing great i think you get a

1269
00:49:43,990 --> 00:49:41,359
million bazillion

1270
00:49:44,790 --> 00:49:44,000
points congratulations we can move on to

1271
00:49:49,430 --> 00:49:44,800
level two

1272
00:49:53,349 --> 00:49:51,349
okay so remember what clara said earlier

1273
00:49:56,630 --> 00:49:53,359
exoplanets are planets

1274
00:49:58,630 --> 00:49:56,640
uh that are in other solar systems and

1275
00:50:00,630 --> 00:49:58,640
they transit when they cross in front of

1276
00:50:02,150 --> 00:50:00,640
their host star and block some of the

1277
00:50:04,150 --> 00:50:02,160
light

1278
00:50:05,589 --> 00:50:04,160
so first i want to show you this

1279
00:50:07,589 --> 00:50:05,599
idealized example

1280
00:50:08,630 --> 00:50:07,599
of what a transit sounds like and we

1281
00:50:10,390 --> 00:50:08,640
heard some earlier

1282
00:50:12,470 --> 00:50:10,400
uh this one's a little bit more drawn

1283
00:50:13,910 --> 00:50:12,480
out so you could hear the detail

1284
00:50:16,630 --> 00:50:13,920
and what a transit sounds like as a

1285
00:50:19,030 --> 00:50:16,640
reminder is it starts at a high pitch

1286
00:50:20,470 --> 00:50:19,040
it deepens as the planet transits in

1287
00:50:25,940 --> 00:50:20,480
front and then it returns to the

1288
00:50:30,710 --> 00:50:25,950

original pitch

1289
00:50:35,270 --> 00:50:33,510
okay so that's what an idealized example

1290
00:50:37,630 --> 00:50:35,280
of a transit sounds like

1291
00:50:39,030 --> 00:50:37,640
so in this round i'm going to play four

1292
00:50:42,069 --> 00:50:39,040
sonifications

1293
00:50:44,230 --> 00:50:42,079
after each sonification i'll ask you how

1294
00:50:46,309 --> 00:50:44,240
many times you heard the exoplanet

1295
00:50:47,829 --> 00:50:46,319
transit so this is a counting one again

1296
00:50:50,069 --> 00:50:47,839
very similar to the final question in

1297
00:50:51,990 --> 00:50:50,079
the flares if you're watching live

1298
00:50:53,430 --> 00:50:52,000
please write the number in the chat so i

1299
00:50:55,030 --> 00:50:53,440
could see how you're doing

1300
00:50:57,270 --> 00:50:55,040
and if you're watching this archive

1301
00:50:58,950 --> 00:50:57,280
later on youtube click the link below

1302
00:51:02,390 --> 00:50:58,960
and start sharing your responses with us

1303
00:51:06,309 --> 00:51:05,510
okay so question one how many transits

1304
00:51:07,990 --> 00:51:06,319
do you count

1305
00:51:25,910 --> 00:51:08,000
write in the chat or respond in the

1306
00:51:29,030 --> 00:51:27,430
what did you all think how many did you

1307
00:51:30,470 --> 00:51:29,040
count

1308
00:51:36,790 --> 00:51:30,480
okay i'll give you a few seconds to

1309
00:51:38,870 --> 00:51:36,800
respond before we reveal the answer

1310
00:51:39,990 --> 00:51:38,880
okay let's see if any chats are coming

1311
00:51:43,190 --> 00:51:40,000
in yet

1312
00:51:44,870 --> 00:51:43,200
huh well i think it's time to move

1313
00:51:47,829 --> 00:51:44,880

forward let's reveal it how many

1314
00:51:50,710 --> 00:51:47,839
transits were there

1315
00:51:52,549 --> 00:51:50,720
five there was five transits and i'll

1316
00:51:57,750 --> 00:51:52,559
make note verbally as we pass through

1317
00:51:57,760 --> 00:52:02,950
one two

1318
00:52:02,960 --> 00:52:08,150
three four

1319
00:52:11,510 --> 00:52:10,710
five and so you can hear that really

1320
00:52:14,950 --> 00:52:11,520
clear dip

1321
00:52:17,990 --> 00:52:14,960
as uh the transit happens okay let's

1322
00:52:20,150 --> 00:52:18,000
move on to the next question

1323
00:52:22,309 --> 00:52:20,160
oh and i see a lot of you are getting

1324
00:52:30,829 --> 00:52:22,319
that one right so that's awesome

1325
00:52:30,839 --> 00:52:46,230
count

1326
00:52:49,430 --> 00:52:48,630
okay what do you think how many transits

1327
00:52:51,430 --> 00:52:49,440
were there

1328
00:52:53,430 --> 00:52:51,440
let me give you a few seconds to write

1329
00:52:58,390 --> 00:52:53,440
that in the chat

1330
00:53:06,950 --> 00:53:03,910
and let's reveal it how many were there

1331
00:53:08,470 --> 00:53:06,960
there was 19 transits so i'm going to

1332
00:53:09,109 --> 00:53:08,480
play it again i'm not going to count as

1333
00:53:11,510 --> 00:53:09,119
each one

1334
00:53:13,990 --> 00:53:11,520
but you'll hear a repeating beat almost

1335
00:53:36,150 --> 00:53:14,000
as at a very regular cadence as the

1336
00:53:39,589 --> 00:53:38,390
okay yeah and i see the answers coming

1337
00:53:42,870 --> 00:53:39,599
in now a lot of you

1338
00:53:44,549 --> 00:53:42,880

heard 19 so fantastic job an extra

1339
00:53:47,430 --> 00:53:44,559
million points to you all

1340
00:54:01,349 --> 00:53:47,440
okay question three how many transits do

1341
00:54:05,030 --> 00:54:03,109
oh i heard a little extra something at

1342
00:54:05,910 --> 00:54:05,040
the end of that one how many transits do

1343
00:54:10,549 --> 00:54:05,920
you count let's

1344
00:54:13,349 --> 00:54:10,559
uh give you a few seconds to respond

1345
00:54:17,190 --> 00:54:13,359
remember in the chat or in the survey

1346
00:54:17,200 --> 00:54:20,710
okay let's find out

1347
00:54:24,870 --> 00:54:23,670
there was three transits and i think

1348
00:54:27,109 --> 00:54:24,880
some of you might have heard that little

1349
00:54:28,710 --> 00:54:27,119
extra flare at the end which you can see

1350
00:54:30,870 --> 00:54:28,720
visually on the right hand side of the

1351
00:54:32,150 --> 00:54:30,880
screen so i'll point out these three

1352
00:54:36,829 --> 00:54:32,160
transits in the flare as

1353
00:54:36,839 --> 00:54:40,069
one

1354
00:54:40,079 --> 00:54:43,270
two

1355
00:54:47,910 --> 00:54:45,430
three and there was a little flare at

1356
00:54:51,030 --> 00:54:47,920
the end the high-pitched flip

1357
00:54:51,750 --> 00:54:51,040
okay seems like a lot of you are saying

1358
00:54:54,950 --> 00:54:51,760
three it's

1359
00:54:55,670 --> 00:54:54,960
awesome okay so this is the final

1360
00:54:57,829 --> 00:54:55,680
question

1361
00:54:59,750 --> 00:54:57,839
and i want to warn you all this final

1362
00:55:01,670 --> 00:54:59,760
light curve is a real challenge

1363
00:55:03,510 --> 00:55:01,680

it is a lot more difficult than the

1364
00:55:05,030 --> 00:55:03,520
others and i even have trouble hearing

1365
00:55:05,750 --> 00:55:05,040
it and i'm working with this data quite

1366
00:55:10,069 --> 00:55:05,760
a lot

1367
00:55:10,079 --> 00:55:16,490
so here we go how many transits do you

1368
00:55:26,549 --> 00:55:18,829
[Music]

1369
00:55:30,630 --> 00:55:28,309
how many transits did you hear what do

1370
00:55:33,589 --> 00:55:30,640
you think

1371
00:55:34,549 --> 00:55:33,599
that's a tough one and so i'm actually

1372
00:55:36,549 --> 00:55:34,559
going to

1373
00:55:38,390 --> 00:55:36,559
try to replay this one once more just to

1374
00:55:50,010 --> 00:55:38,400
give you a second chance to listen

1375
00:55:50,020 --> 00:55:56,870
[Music]

1376
00:56:01,510 --> 00:56:00,390
so okay on that second listen were you

1377
00:56:03,430 --> 00:56:01,520
able to hear it

1378
00:56:05,109 --> 00:56:03,440
it's pretty tough okay so i'm seeing

1379
00:56:10,230 --> 00:56:05,119
some numbers come in

1380
00:56:15,190 --> 00:56:13,430
so there was three transits and i want

1381
00:56:16,150 --> 00:56:15,200
to explain what's going on with this

1382
00:56:17,670 --> 00:56:16,160
star

1383
00:56:19,510 --> 00:56:17,680
you can kind of visually see where they

1384
00:56:19,990 --> 00:56:19,520
are and they're not all at the lowest

1385
00:56:22,870 --> 00:56:20,000
step

1386
00:56:24,950 --> 00:56:22,880
in this slide curve so the baseline

1387
00:56:27,349 --> 00:56:24,960
light coming from the star has its own

1388
00:56:29,510 --> 00:56:27,359

undulating up and down pattern in

1389
00:56:31,190 --> 00:56:29,520
addition to the transit

1390
00:56:32,870 --> 00:56:31,200
it's possibly caused by something like

1391
00:56:36,150 --> 00:56:32,880
star spots which

1392
00:56:38,069 --> 00:56:36,160
are areas with more or less light so

1393
00:56:40,390 --> 00:56:38,079
as the star spins on its axis the

1394
00:56:42,150 --> 00:56:40,400
sonification is representing this up and

1395
00:56:43,750 --> 00:56:42,160
down pattern of the brighter and dimmer

1396
00:56:46,150 --> 00:56:43,760
areas

1397
00:56:47,589 --> 00:56:46,160
as the star's spinning the star spot

1398
00:56:49,829 --> 00:56:47,599
might pass and

1399
00:56:51,589 --> 00:56:49,839
you know deepen or brighten the light

1400
00:56:53,349 --> 00:56:51,599
and so this is happening regularly

1401
00:56:55,190 --> 00:56:53,359
and in addition a planet is also

1402
00:56:57,109 --> 00:56:55,200
transiting in front

1403
00:56:58,950 --> 00:56:57,119
so this sonification is a really great

1404
00:57:01,589 --> 00:56:58,960
example about how studying data

1405
00:57:02,630 --> 00:57:01,599
in multi-modal ways can enhance our

1406
00:57:04,870 --> 00:57:02,640
understanding

1407
00:57:06,549 --> 00:57:04,880
because in some cases audio draws our

1408
00:57:07,349 --> 00:57:06,559
attention to qualities we couldn't see

1409
00:57:09,349 --> 00:57:07,359
in a graph

1410
00:57:10,549 --> 00:57:09,359
but in others it's easier to see it than

1411
00:57:12,630 --> 00:57:10,559
to hear

1412
00:57:14,390 --> 00:57:12,640
so there's a place for sonification and

1413
00:57:15,109 --> 00:57:14,400

a place for visualization but most

1414
00:57:18,230 --> 00:57:15,119
powerfully

1415
00:57:20,549 --> 00:57:18,240
is when we combine the two

1416
00:57:22,309 --> 00:57:20,559
so i'm gonna take a look at the chat and

1417
00:57:23,750 --> 00:57:22,319
see if anyone got that last one let's

1418
00:57:25,109 --> 00:57:23,760
see

1419
00:57:26,950 --> 00:57:25,119
i saw some people got three a lot of

1420
00:57:28,549 --> 00:57:26,960
people thought four

1421
00:57:31,109 --> 00:57:28,559
okay i bet you were hearing the the

1422
00:57:34,549 --> 00:57:31,119
undulation the overall star's brightness

1423
00:57:37,030 --> 00:57:34,559
uh okay awesome so let's move on

1424
00:57:37,990 --> 00:57:37,040
past this um i hope you all enjoyed

1425
00:57:42,069 --> 00:57:38,000
playing

1426
00:57:42,079 --> 00:57:44,910
there's the second one

1427
00:57:44,920 --> 00:57:49,109
[Music]

1428
00:57:54,309 --> 00:57:52,630
okay so for me i'm clearly able to hear

1429
00:57:55,910 --> 00:57:54,319
the second one but it's hard for me to

1430
00:58:02,380 --> 00:57:55,920
hear the first and second so here let's

1431
00:58:02,390 --> 00:58:06,829
[Music]

1432
00:58:11,750 --> 00:58:08,490
again

1433
00:58:13,990 --> 00:58:11,760
[Music]

1434
00:58:15,670 --> 00:58:14,000
okay so there you are that one was a

1435
00:58:17,190 --> 00:58:15,680
pretty tough one

1436
00:58:19,430 --> 00:58:17,200
i really hope you enjoyed playing this

1437
00:58:21,030 --> 00:58:19,440
game and if you like listening to data

1438
00:58:22,870 --> 00:58:21,040

and answering questions like these

1439
00:58:26,270 --> 00:58:22,880
i encourage you to go to our website

1440
00:58:27,829 --> 00:58:26,280
which is astronomify

1441
00:58:30,950 --> 00:58:27,839
a-s-t-r-o-n-i-f-y

1442
00:58:34,230 --> 00:58:30,960
dot read the docs read the docs

1443
00:58:34,630 --> 00:58:34,240
dot io and if you scroll down there's a

1444
00:58:37,270 --> 00:58:34,640
game

1445
00:58:37,670 --> 00:58:37,280
section level one is very similar to

1446
00:58:39,270 --> 00:58:37,680
what

1447
00:58:41,109 --> 00:58:39,280
you just did the exercise you just

1448
00:58:43,349 --> 00:58:41,119
played but level two

1449
00:58:44,150 --> 00:58:43,359
is a totally different one and it

1450
00:58:47,190 --> 00:58:44,160
focuses

1451
00:58:47,990 --> 00:58:47,200
on exoplanets and dives deeper into ways

1452
00:58:51,030 --> 00:58:48,000
you can listen and

1453
00:58:52,710 --> 00:58:51,040
analyze transiting exoplanet data

1454
00:58:54,150 --> 00:58:52,720
and at the end you'll find out what the

1455
00:58:55,589 --> 00:58:54,160
correct and incorrect answers were and

1456
00:58:57,430 --> 00:58:55,599
how you did

1457
00:58:59,910 --> 00:58:57,440
so and once again these survey results

1458
00:59:02,549 --> 00:58:59,920
really uh give us fantastic feedback

1459
00:59:03,990 --> 00:59:02,559
and we can help learn how to improve the

1460
00:59:08,150 --> 00:59:04,000
sonification so thank you

1461
00:59:12,069 --> 00:59:10,630
and finally just want to quickly tell

1462
00:59:13,349 --> 00:59:12,079
you about this

1463
00:59:15,270 --> 00:59:13,359

other part of our project which are

1464
00:59:16,950 --> 00:59:15,280
these interactive exhibits

1465
00:59:18,789 --> 00:59:16,960
main goal of this project has been to

1466
00:59:19,829 --> 00:59:18,799
bring astronomy and sonification to a

1467
00:59:22,150 --> 00:59:19,839
wider audience

1468
00:59:23,670 --> 00:59:22,160
and to that end we're working on three

1469
00:59:25,190 --> 00:59:23,680
interactive sculptures that we could

1470
00:59:26,630 --> 00:59:25,200
show at local events

1471
00:59:29,109 --> 00:59:26,640
and we also want to bring them on the

1472
00:59:30,870 --> 00:59:29,119
road to classrooms and conferences

1473
00:59:32,710 --> 00:59:30,880
and as with the rest of our project we

1474
00:59:35,030 --> 00:59:32,720
want to make sure these exhibits

1475
00:59:36,309 --> 00:59:35,040
are accessible to blind and low vision

1476
00:59:37,990 --> 00:59:36,319
people

1477
00:59:40,150 --> 00:59:38,000
we are so excited to be working with

1478
00:59:42,630 --> 00:59:40,160
bill haas who is a museum

1479
00:59:43,349 --> 00:59:42,640
exhibit designer extraordinaire this guy

1480
00:59:45,670 --> 00:59:43,359
can build

1481
00:59:47,430 --> 00:59:45,680
anything his day job is actually

1482
00:59:50,309 --> 00:59:47,440
designing museum exhibits for the

1483
00:59:51,829 --> 00:59:50,319
smithsonian air and space museum in dc

1484
00:59:55,109 --> 00:59:51,839
so we're so excited to be working with

1485
00:59:59,190 --> 00:59:55,119
him unfortunately covid happened

1486
01:00:01,190 --> 00:59:59,200
what a drag it's pretty awful but

1487
01:00:02,950 --> 01:00:01,200
so we've kind of slowed down the process

1488
01:00:05,270 --> 01:00:02,960

for these in-person exhibits

1489
01:00:06,470 --> 01:00:05,280
because clearly gatherings of people who

1490
01:00:09,430 --> 01:00:06,480
are all touching the same

1491
01:00:10,549 --> 01:00:09,440
sculptures is no longer uh advisable at

1492
01:00:12,309 --> 01:00:10,559
this moment in time

1493
01:00:14,309 --> 01:00:12,319
we're still making some progress and we

1494
01:00:15,270 --> 01:00:14,319
are excited to do more with this in the

1495
01:00:17,510 --> 01:00:15,280
future

1496
01:00:18,390 --> 01:00:17,520
so this image that we're showing on the

1497
01:00:21,109 --> 01:00:18,400
slide

1498
01:00:22,870 --> 01:00:21,119
is an in progress sculpture and it's the

1499
01:00:25,670 --> 01:00:22,880
exhibit i'm most excited about

1500
01:00:26,789 --> 01:00:25,680
it's a light curved xylophone the

1501
01:00:28,789 --> 01:00:26,799
instrument is built

1502
01:00:30,630 --> 01:00:28,799
in the shape of a light curve and as you

1503
01:00:31,270 --> 01:00:30,640
play the instrument you run your hand

1504
01:00:33,430 --> 01:00:31,280
along

1505
01:00:35,109 --> 01:00:33,440
the shape which is a great way to

1506
01:00:37,430 --> 01:00:35,119
physically understand

1507
01:00:40,230 --> 01:00:37,440
uh the shape of a light curve and then

1508
01:00:42,470 --> 01:00:40,240
as you're making the noise it's actually

1509
01:00:43,349 --> 01:00:42,480
creating music in the sound that we

1510
01:00:46,309 --> 01:00:43,359
would sonify

1511
01:00:47,990 --> 01:00:46,319
so a higher pitch for more light lower

1512
01:00:49,910 --> 01:00:48,000
pitch for less light

1513
01:00:51,349 --> 01:00:49,920

so it's in progress and the sounds still

1514
01:00:53,190 --> 01:00:51,359
need a little bit of tweaking

1515
01:00:54,549 --> 01:00:53,200
but i can't tell you how excited i am

1516
01:00:56,870 --> 01:00:54,559
about the sculpture

1517
01:01:09,109 --> 01:00:56,880
and i have a short video to show you to

1518
01:01:14,950 --> 01:01:13,030
okay so that's um

1519
01:01:16,230 --> 01:01:14,960
that's that portion of the project if

1520
01:01:17,829 --> 01:01:16,240
you're excited about the things you've

1521
01:01:19,990 --> 01:01:17,839
been hearing in this presentation

1522
01:01:20,950 --> 01:01:20,000
i want to invite you to join us

1523
01:01:23,589 --> 01:01:20,960
astronomify

1524
01:01:25,750 --> 01:01:23,599
is a python package that we built to

1525
01:01:27,109 --> 01:01:25,760
sonify our data and by we i mean clara

1526
01:01:30,309 --> 01:01:27,119
clara has built it

1527
01:01:33,270 --> 01:01:30,319
um mostly by herself very impressive

1528
01:01:34,470 --> 01:01:33,280
uh so it is open source and you could

1529
01:01:35,990 --> 01:01:34,480
find it on github

1530
01:01:37,670 --> 01:01:36,000
and if you're familiar with python

1531
01:01:39,829 --> 01:01:37,680
coding i encourage you to try

1532
01:01:40,789 --> 01:01:39,839
installing it and to sonify your own

1533
01:01:42,789 --> 01:01:40,799
data

1534
01:01:44,549 --> 01:01:42,799
we also welcome contributions if that's

1535
01:01:45,990 --> 01:01:44,559
something you're into

1536
01:01:47,750 --> 01:01:46,000
and also if you're just generally

1537
01:01:49,510 --> 01:01:47,760
interested in this project excited about

1538
01:01:51,589 --> 01:01:49,520

sonification and space

1539
01:01:53,109 --> 01:01:51,599
whether you code or not i encourage you

1540
01:01:54,710 --> 01:01:53,119
to check out our website

1541
01:01:56,870 --> 01:01:54,720
and join our mailing list so you can

1542
01:01:58,230 --> 01:01:56,880
listen to more sonifications hear about

1543
01:02:00,789 --> 01:01:58,240
project updates

1544
01:02:01,270 --> 01:02:00,799
and feature events like this one once

1545
01:02:04,950 --> 01:02:01,280
again

1546
01:02:09,349 --> 01:02:04,960
uh the website is astronofy

1547
01:02:12,549 --> 01:02:09,359
r o a-s-t-r-o-n i f y dot read the docs

1548
01:02:14,069 --> 01:02:12,559
dot io thank you all so much for tuning

1549
01:02:15,910 --> 01:02:14,079
in to this presentation

1550
01:02:17,190 --> 01:02:15,920
we are very excited to answer whatever

1551
01:02:20,150 --> 01:02:17,200
questions you may have

1552
01:02:21,670 --> 01:02:20,160
so thank you all right thank you very

1553
01:02:23,990 --> 01:02:21,680
much jen that was

1554
01:02:25,029 --> 01:02:24,000
really really a lot of fun i was

1555
01:02:27,029 --> 01:02:25,039
watching the chat

1556
01:02:28,789 --> 01:02:27,039
and everybody seemed to have a blast

1557
01:02:31,270 --> 01:02:28,799
playing this little game show

1558
01:02:32,630 --> 01:02:31,280
uh to go along with it so this is one of

1559
01:02:35,430 --> 01:02:32,640
the first times we've done this at the

1560
01:02:37,430 --> 01:02:35,440
public lecture series not only

1561
01:02:39,670 --> 01:02:37,440
given them information but actually let

1562
01:02:41,349 --> 01:02:39,680
them utilize that information so thank

1563
01:02:44,069 --> 01:02:41,359

you all for a

1564
01:02:45,750 --> 01:02:44,079
wonderful presentation and one of the

1565
01:02:46,950 --> 01:02:45,760
questions that somebody asked on there

1566
01:02:50,069 --> 01:02:46,960
was well the same question

1567
01:02:52,069 --> 01:02:50,079
i had was um just can we get an

1568
01:02:53,430 --> 01:02:52,079
idea of what inspired you to do this

1569
01:02:56,390 --> 01:02:53,440
sonification were there other

1570
01:02:57,670 --> 01:02:56,400
projects that you saw that um that that

1571
01:02:59,589 --> 01:02:57,680
pulled you into this

1572
01:03:01,109 --> 01:02:59,599
um you know i'd like to hear from each

1573
01:03:02,710 --> 01:03:01,119
one each one of you as to you know

1574
01:03:04,789 --> 01:03:02,720
what what what brought you into this

1575
01:03:07,990 --> 01:03:04,799
what what what what pulled you into

1576
01:03:11,109 --> 01:03:10,150
yeah i like to have maybe uh jen and

1577
01:03:13,270 --> 01:03:11,119
then clara

1578
01:03:14,390 --> 01:03:13,280
uh and then i'll i'll if i have time

1579
01:03:16,390 --> 01:03:14,400
i'll go through the

1580
01:03:17,750 --> 01:03:16,400
the inspiration for me so maybe jen do

1581
01:03:19,589 --> 01:03:17,760
you want to say something about

1582
01:03:21,910 --> 01:03:19,599
what inspires you to work on the project

1583
01:03:23,029 --> 01:03:21,920
yeah i mean so i have i come from an art

1584
01:03:25,109 --> 01:03:23,039
background i have a bit of an

1585
01:03:27,349 --> 01:03:25,119
untraditional background for working

1586
01:03:29,109 --> 01:03:27,359
at a space telescope science institute

1587
01:03:32,710 --> 01:03:29,119
where it's mostly people

1588
01:03:34,870 --> 01:03:32,720

who are developers and scientists and so

1589
01:03:37,029 --> 01:03:34,880
um i'm really excited about the idea of

1590
01:03:38,150 --> 01:03:37,039
trying to create art with data

1591
01:03:40,390 --> 01:03:38,160
and you know different ways of

1592
01:03:41,510 --> 01:03:40,400
visualizing data and it's been something

1593
01:03:43,750 --> 01:03:41,520
i've been thinking about

1594
01:03:45,829 --> 01:03:43,760
and we had this great public lecture by

1595
01:03:48,870 --> 01:03:45,839
this fellow named gary forran

1596
01:03:50,150 --> 01:03:48,880
who is a phd candidate and uh swinborn i

1597
01:03:52,309 --> 01:03:50,160
believe in australia

1598
01:03:53,750 --> 01:03:52,319
and he came in to talk to us about the

1599
01:03:55,750 --> 01:03:53,760
project he's working on

1600
01:03:57,510 --> 01:03:55,760
because he's actually blind and he's

1601
01:04:00,710 --> 01:03:57,520
working on his physics degree

1602
01:04:02,789 --> 01:04:00,720
and so he's working on studying data but

1603
01:04:05,190 --> 01:04:02,799
i think he was struggling he was

1604
01:04:07,109 --> 01:04:05,200
probably needing people to

1605
01:04:08,549 --> 01:04:07,119
verbally describe what they were seeing

1606
01:04:11,029 --> 01:04:08,559
on charts and graphs

1607
01:04:12,069 --> 01:04:11,039
and so he and a few other people are

1608
01:04:15,589 --> 01:04:12,079
working together

1609
01:04:18,549 --> 01:04:15,599
on sonification and he gave a talk about

1610
01:04:20,230 --> 01:04:18,559
all the promise that he that it has and

1611
01:04:22,230 --> 01:04:20,240
he played some sonifications

1612
01:04:24,069 --> 01:04:22,240
and i was just really excited and

1613
01:04:25,430 --> 01:04:24,079

inspired to hear this and

1614
01:04:28,309 --> 01:04:25,440
i mean both from the accessibility

1615
01:04:30,470 --> 01:04:28,319
standard of course but also

1616
01:04:31,990 --> 01:04:30,480
just imagining the the art and the

1617
01:04:33,990 --> 01:04:32,000
interactivity and it's such an amazing

1618
01:04:38,390 --> 01:04:34,000
way of putting you inside data

1619
01:04:42,230 --> 01:04:40,870
all right clara you have a any any

1620
01:04:45,670 --> 01:04:42,240
anything to add

1621
01:04:47,589 --> 01:04:45,680
yeah so i i mean i do have a physics

1622
01:04:49,190 --> 01:04:47,599
background and i work at space telescope

1623
01:04:50,150 --> 01:04:49,200
but i also have a music composition

1624
01:04:53,510 --> 01:04:50,160
background

1625
01:04:56,150 --> 01:04:53,520
and so um day to day sonification

1626
01:04:57,670 --> 01:04:56,160
when you know i learned about it as a

1627
01:04:58,870 --> 01:04:57,680
thing it was something that i was very

1628
01:05:01,589 --> 01:04:58,880
interested in and

1629
01:05:02,950 --> 01:05:01,599
i've done some sort of electronic music

1630
01:05:06,549 --> 01:05:02,960
in the past and so

1631
01:05:08,390 --> 01:05:06,559
is very um you know i i used to use

1632
01:05:09,589 --> 01:05:08,400
random numbers and things as as

1633
01:05:11,270 --> 01:05:09,599
inspiration so

1634
01:05:12,789 --> 01:05:11,280
so it was like oh yes this is something

1635
01:05:14,309 --> 01:05:12,799
that would be cool to play around with

1636
01:05:15,990 --> 01:05:14,319
and i actually missed gary's talk

1637
01:05:16,710 --> 01:05:16,000
because i think i was out of town at the

1638
01:05:18,230 --> 01:05:16,720

time

1639
01:05:20,870 --> 01:05:18,240
and so jen was like well this was

1640
01:05:23,349 --> 01:05:20,880
amazing and we should meet this person

1641
01:05:25,190 --> 01:05:23,359
and then scott had who's gonna talk last

1642
01:05:26,630 --> 01:05:25,200
but scott had the idea for this project

1643
01:05:28,230 --> 01:05:26,640
and was like you seem like you might be

1644
01:05:30,069 --> 01:05:28,240
interested and i was like yes i

1645
01:05:32,309 --> 01:05:30,079
definitely want to do this

1646
01:05:34,870 --> 01:05:32,319
um and i also since jen brought up that

1647
01:05:36,470 --> 01:05:34,880
gary is working on sonification

1648
01:05:38,549 --> 01:05:36,480
one of the goals of this project that

1649
01:05:41,990 --> 01:05:38,559
hasn't been coded yet because

1650
01:05:45,349 --> 01:05:42,000
these things take time is that is to

1651
01:05:45,750 --> 01:05:45,359
have the the software that he's working

1652
01:05:47,510 --> 01:05:45,760
on

1653
01:05:49,430 --> 01:05:47,520
isn't isn't something that can be really

1654
01:05:51,910 --> 01:05:49,440
run through the web

1655
01:05:53,670 --> 01:05:51,920
and you have to bring the data to it and

1656
01:05:55,349 --> 01:05:53,680
it has to come into it in specific

1657
01:05:56,630 --> 01:05:55,359
format so one of the things we want to

1658
01:05:58,630 --> 01:05:56,640
add to our

1659
01:06:00,309 --> 01:05:58,640
software is the ability to write out the

1660
01:06:03,910 --> 01:06:00,319
configuration files

1661
01:06:04,710 --> 01:06:03,920
for his star sound so that it can be a

1662
01:06:07,750 --> 01:06:04,720
through line

1663
01:06:10,390 --> 01:06:07,760

to easily get data from

1664
01:06:12,309 --> 01:06:10,400
mass and then sauna and then sonify it

1665
01:06:14,230 --> 01:06:12,319
and we are providing you know

1666
01:06:15,349 --> 01:06:14,240
python sonification because that is a

1667
01:06:17,430 --> 01:06:15,359
very popular

1668
01:06:19,349 --> 01:06:17,440
language in astronomy but we also like

1669
01:06:20,710 --> 01:06:19,359
one of our goals as part of our

1670
01:06:22,470 --> 01:06:20,720
accessibility goal is to be

1671
01:06:23,670 --> 01:06:22,480
interoperable with the other projects

1672
01:06:25,270 --> 01:06:23,680
that are out there

1673
01:06:26,789 --> 01:06:25,280
um because there are a lot of different

1674
01:06:29,109 --> 01:06:26,799
ways to sonify with a lot of different

1675
01:06:31,990 --> 01:06:29,119
strengths and weaknesses depending on

1676
01:06:32,630 --> 01:06:32,000
what specific task you're looking for

1677
01:06:34,789 --> 01:06:32,640
all right

1678
01:06:35,910 --> 01:06:34,799
fantastic scott how about you finish us

1679
01:06:37,029 --> 01:06:35,920
up on this question

1680
01:06:38,870 --> 01:06:37,039
i'll try and do the short version

1681
01:06:39,990 --> 01:06:38,880
there's a lot of other questions but um

1682
01:06:41,589 --> 01:06:40,000
yeah i was

1683
01:06:43,109 --> 01:06:41,599
we go to an annual meeting every year

1684
01:06:46,069 --> 01:06:43,119
and i like to go up and down all the

1685
01:06:48,549 --> 01:06:46,079
posters and i stumbled across

1686
01:06:50,069 --> 01:06:48,559
kate's poster uh kate meredith who's in

1687
01:06:50,950 --> 01:06:50,079
the chat as well as bill our other two

1688
01:06:53,589 --> 01:06:50,960

teammates

1689
01:06:54,789 --> 01:06:53,599
um so great work on them and and i ran

1690
01:06:57,670 --> 01:06:54,799
across the student who

1691
01:06:59,190 --> 01:06:57,680
was giving this demo of showing how

1692
01:07:02,470 --> 01:06:59,200
constellations could be

1693
01:07:03,990 --> 01:07:02,480
shown on an umbrella with things stuck

1694
01:07:05,990 --> 01:07:04,000
on the umbrellas that you could touch

1695
01:07:07,829 --> 01:07:06,000
and feel the constellations for those

1696
01:07:09,589 --> 01:07:07,839
who were blind and you could spin the

1697
01:07:10,150 --> 01:07:09,599
umbrella which looks like a dome and

1698
01:07:12,789 --> 01:07:10,160
really

1699
01:07:14,230 --> 01:07:12,799
get a sense of how the sky moves from

1700
01:07:15,430 --> 01:07:14,240
touch and that was just a fantastic

1701
01:07:17,990 --> 01:07:15,440
conversation

1702
01:07:19,029 --> 01:07:18,000
so that combined that that was sort of

1703
01:07:20,390 --> 01:07:19,039
started our relation a working

1704
01:07:21,270 --> 01:07:20,400
relationship with kate and glass

1705
01:07:23,589 --> 01:07:21,280
education

1706
01:07:25,029 --> 01:07:23,599
and then that combined with um my dad

1707
01:07:26,870 --> 01:07:25,039
did some volunteer work for the lions

1708
01:07:28,309 --> 01:07:26,880
club which is a volunteer organization

1709
01:07:30,470 --> 01:07:28,319
here in the united states

1710
01:07:32,150 --> 01:07:30,480
that has done a lot of work for um for

1711
01:07:32,950 --> 01:07:32,160
people who are blind and low vision and

1712
01:07:35,990 --> 01:07:32,960
i guess i

1713
01:07:37,109 --> 01:07:36,000

took on that sort of interest as well um

1714
01:07:38,390 --> 01:07:37,119
but yeah i want to make it clear to

1715
01:07:39,750 --> 01:07:38,400
everybody we are not the people who have

1716
01:07:41,190 --> 01:07:39,760
invented sonification

1717
01:07:42,870 --> 01:07:41,200
people been working on solidification

1718
01:07:44,789 --> 01:07:42,880
for decades um

1719
01:07:46,309 --> 01:07:44,799
but you know we're we're taking a lot of

1720
01:07:47,270 --> 01:07:46,319
that work and and trying to make it part

1721
01:07:50,470 --> 01:07:47,280
of the archive

1722
01:07:52,470 --> 01:07:50,480
so yeah all right fantastic all right so

1723
01:07:54,549 --> 01:07:52,480
grant justice has been monitoring the

1724
01:07:57,109 --> 01:07:54,559
chat more closely than any of us

1725
01:07:58,710 --> 01:07:57,119
and grant why don't you come join us and

1726
01:08:01,109 --> 01:07:58,720
tell us the questions you found in the

1727
01:08:03,270 --> 01:08:01,119
chat for the group

1728
01:08:06,150 --> 01:08:03,280
absolutely first off i would just like

1729
01:08:08,829 --> 01:08:06,160
to say thank you to the audience because

1730
01:08:10,470 --> 01:08:08,839
we had some great answers and some great

1731
01:08:15,589 --> 01:08:10,480
interaction um

1732
01:08:18,950 --> 01:08:17,110
so on one of the first graphs that you

1733
01:08:19,749 --> 01:08:18,960
see that you put up i believe it was the

1734
01:08:22,470 --> 01:08:19,759
very first

1735
01:08:25,510 --> 01:08:22,480
sonification graph what is the

1736
01:08:27,349 --> 01:08:25,520
explanation for the decreasing slope

1737
01:08:30,229 --> 01:08:27,359
of the relative lower values of

1738
01:08:32,789 --> 01:08:30,239

oscillating star brightness

1739
01:08:33,749 --> 01:08:32,799
yeah i'll take a stab at that one first

1740
01:08:35,910 --> 01:08:33,759
um

1741
01:08:38,229 --> 01:08:35,920
so i think the the the person there

1742
01:08:40,709 --> 01:08:38,239
noted that in addition to the pattern

1743
01:08:42,550 --> 01:08:40,719
there was a sort of trend as well and

1744
01:08:43,110 --> 01:08:42,560
and i don't have a direct answer for

1745
01:08:45,590 --> 01:08:43,120
that but

1746
01:08:47,349 --> 01:08:45,600
uh it one thing to point out was it was

1747
01:08:48,950 --> 01:08:47,359
zoomed in and so if we zoomed out the

1748
01:08:51,910 --> 01:08:48,960
full light curve which

1749
01:08:53,430 --> 01:08:51,920
uh if it's kepler or tess they they

1750
01:08:57,269 --> 01:08:53,440
observe the targets

1751
01:09:00,070 --> 01:08:57,279
every half an hour for months at a time

1752
01:09:01,669 --> 01:09:00,080
continuously and so you could actually

1753
01:09:04,309 --> 01:09:01,679
see a better pattern now whether that

1754
01:09:05,749 --> 01:09:04,319
undulating pattern is something real

1755
01:09:05,990 --> 01:09:05,759
going on with the star itself which it

1756
01:09:08,789 --> 01:09:06,000
might

1757
01:09:09,910 --> 01:09:08,799
be or sort of some calibration that

1758
01:09:12,950 --> 01:09:09,920
wasn't perfectly done

1759
01:09:14,070 --> 01:09:12,960
we'd have to investigate um but i i do

1760
01:09:15,990 --> 01:09:14,080
think there is an unjuly

1761
01:09:17,590 --> 01:09:16,000
undulating pattern that you saw even in

1762
01:09:19,269 --> 01:09:17,600
the zoomed in version

1763
01:09:20,789 --> 01:09:19,279

whether that's sort of not perfect

1764
01:09:22,229 --> 01:09:20,799
calibration or something real we'd have

1765
01:09:23,990 --> 01:09:22,239
to do some real science behind it but

1766
01:09:25,590 --> 01:09:24,000
that was a good observation and many

1767
01:09:26,550 --> 01:09:25,600
times those patterns are real

1768
01:09:29,590 --> 01:09:26,560
and they tell us something about the

1769
01:09:31,269 --> 01:09:29,600
physics happening right and

1770
01:09:34,709 --> 01:09:31,279
can i just interject are we talking

1771
01:09:37,829 --> 01:09:34,719
about the first light curve on the um

1772
01:09:41,110 --> 01:09:37,839
game show no it was the

1773
01:09:43,269 --> 01:09:41,120
part of the first talk the very first

1774
01:09:46,390 --> 01:09:43,279
one you guys put up

1775
01:09:48,709 --> 01:09:46,400
when we were still explaining

1776
01:09:50,309 --> 01:09:48,719
but scott answered the majority of okay

1777
01:09:53,269 --> 01:09:50,319
because i would say i know at least

1778
01:09:54,229 --> 01:09:53,279
like the kepler 12b one and one and the

1779
01:09:59,350 --> 01:09:54,239
the

1780
01:10:00,709 --> 01:09:59,360
it is it is instrumental because i've

1781
01:10:02,149 --> 01:10:00,719
worked with i've worked with those

1782
01:10:04,870 --> 01:10:02,159
specific light curves

1783
01:10:06,870 --> 01:10:04,880
and there is an artificial trend that

1784
01:10:09,669 --> 01:10:06,880
the kepler data has

1785
01:10:10,950 --> 01:10:09,679
that typically um and i left it in

1786
01:10:11,910 --> 01:10:10,960
intentionally because that's something

1787
01:10:13,750 --> 01:10:11,920
that you have to deal with as an

1788
01:10:16,870 --> 01:10:13,760

astronomer determining whether or not

1789
01:10:21,110 --> 01:10:16,880
it's real and in this case it's it's

1790
01:10:23,669 --> 01:10:21,120
an artifact of of the instrument

1791
01:10:25,270 --> 01:10:23,679
cool that's actually leading me to the

1792
01:10:27,189 --> 01:10:25,280
second one which was

1793
01:10:29,510 --> 01:10:27,199
does the longer scale variation show

1794
01:10:32,790 --> 01:10:29,520
this as well which is what scott just

1795
01:10:36,229 --> 01:10:32,800
elaborated on before we got there so

1796
01:10:38,950 --> 01:10:36,239
um next up who slash

1797
01:10:40,870 --> 01:10:38,960
when did astro sonification come about

1798
01:10:41,750 --> 01:10:40,880
because we use sonification in a lot of

1799
01:10:44,870 --> 01:10:41,760
different methods

1800
01:10:47,830 --> 01:10:44,880
but asternification

1801
01:10:48,790 --> 01:10:47,840
that is a good question uh actually

1802
01:10:50,550 --> 01:10:48,800
probably kate

1803
01:10:52,149 --> 01:10:50,560
if if kate's still in the chat would

1804
01:10:52,950 --> 01:10:52,159
know the best but i want to say it's

1805
01:10:55,510 --> 01:10:52,960
been around

1806
01:10:57,189 --> 01:10:55,520
since at least the mid 90s i think

1807
01:10:58,950 --> 01:10:57,199
there's a pretty seminal paper

1808
01:11:00,310 --> 01:10:58,960
not necessarily about astronomy but

1809
01:11:02,550 --> 01:11:00,320
other types of data

1810
01:11:03,990 --> 01:11:02,560
from i think like 1997 or something like

1811
01:11:06,950 --> 01:11:04,000
that if i'm not mistaken

1812
01:11:07,510 --> 01:11:06,960
um and i i know for a fact over the last

1813
01:11:10,229 --> 01:11:07,520

1814
01:11:11,350 --> 01:11:10,239
or or or even more years there have been

1815
01:11:14,550 --> 01:11:11,360
individuals

1816
01:11:16,550 --> 01:11:14,560
working very hard in ways of

1817
01:11:18,630 --> 01:11:16,560
representing not just light curves like

1818
01:11:20,229 --> 01:11:18,640
we've shown but also people are doing

1819
01:11:21,830 --> 01:11:20,239
work to sonify images

1820
01:11:24,070 --> 01:11:21,840
if you can believe it or not and they

1821
01:11:26,630 --> 01:11:24,080
have some really good solutions for that

1822
01:11:28,709 --> 01:11:26,640
as well as other types of data um so

1823
01:11:30,470 --> 01:11:28,719
it's it's a it's a small but growing

1824
01:11:31,430 --> 01:11:30,480
field and one of the things we're trying

1825
01:11:33,350 --> 01:11:31,440
to do

1826
01:11:35,350 --> 01:11:33,360
um with other groups around the world

1827
01:11:36,870 --> 01:11:35,360
interested in sonification of which i

1828
01:11:37,430 --> 01:11:36,880
saw at least a couple in the chat as

1829
01:11:39,669 --> 01:11:37,440
well

1830
01:11:41,430 --> 01:11:39,679
is to work together to try and pull our

1831
01:11:44,870 --> 01:11:41,440
resources together

1832
01:11:45,910 --> 01:11:44,880
yeah scott says um like when you showed

1833
01:11:48,470 --> 01:11:45,920
that you know you can

1834
01:11:49,990 --> 01:11:48,480
feel the the motion of the sine wave

1835
01:11:52,550 --> 01:11:50,000
with the sound and everything

1836
01:11:54,229 --> 01:11:52,560
um people have uh created several

1837
01:11:56,229 --> 01:11:54,239
sonifications in astronomy

1838
01:11:57,430 --> 01:11:56,239

where you take your mouse and move it

1839
01:11:59,590 --> 01:11:57,440
across the image

1840
01:12:01,430 --> 01:11:59,600
and the sound changes as you go across

1841
01:12:02,229 --> 01:12:01,440
different things to indicate certain

1842
01:12:05,510 --> 01:12:02,239
things like

1843
01:12:06,070 --> 01:12:05,520
the hubble ultra deep field each galaxy

1844
01:12:08,229 --> 01:12:06,080
that you

1845
01:12:10,390 --> 01:12:08,239
come across has a different tone based

1846
01:12:13,189 --> 01:12:10,400
upon the redshift of that galaxy

1847
01:12:13,910 --> 01:12:13,199
for example so you know doing images as

1848
01:12:16,870 --> 01:12:13,920
well as

1849
01:12:17,590 --> 01:12:16,880
light curves uh you know quite a quite a

1850
01:12:20,390 --> 01:12:17,600
variety

1851
01:12:23,030 --> 01:12:20,400
possibilities so you mentioned them

1852
01:12:25,270 --> 01:12:23,040
moving the mouse across the screen

1853
01:12:27,590 --> 01:12:25,280
i know of some blind astronomers who use

1854
01:12:29,189 --> 01:12:27,600
touch pads and some ways of physically

1855
01:12:31,430 --> 01:12:29,199
interacting with

1856
01:12:33,189 --> 01:12:31,440
a piece of hardware that they could

1857
01:12:35,270 --> 01:12:33,199
actually feel

1858
01:12:37,189 --> 01:12:35,280
where they're moving and then the sound

1859
01:12:38,709 --> 01:12:37,199
gives feedback as they run their hand

1860
01:12:41,430 --> 01:12:38,719
over a certain area

1861
01:12:42,149 --> 01:12:41,440
um and then also uh similarly using kind

1862
01:12:44,790 --> 01:12:42,159
of dj

1863
01:12:45,910 --> 01:12:44,800

kits and interacting with the

1864
01:12:48,550 --> 01:12:45,920
sonifications

1865
01:12:50,709 --> 01:12:48,560
and updating them uh with this like

1866
01:12:53,830 --> 01:12:50,719
physical interface

1867
01:12:55,110 --> 01:12:53,840
cool that's so cool what's up grant

1868
01:12:57,669 --> 01:12:55,120
what's next

1869
01:12:58,950 --> 01:12:57,679
all right so next one is kind of a

1870
01:13:01,750 --> 01:12:58,960
continuation as well

1871
01:13:04,149 --> 01:13:01,760
what else do we use sonification for i

1872
01:13:06,470 --> 01:13:04,159
think more specifically in science but

1873
01:13:07,590 --> 01:13:06,480
just as a general like an idea of the

1874
01:13:11,270 --> 01:13:07,600
usage for

1875
01:13:14,070 --> 01:13:11,280
the audience i know so many things

1876
01:13:15,590 --> 01:13:14,080
sorry go ahead i was going to say from

1877
01:13:18,229 --> 01:13:15,600
my experience i know that it's

1878
01:13:19,830 --> 01:13:18,239
used in testing for like pressure cracks

1879
01:13:23,830 --> 01:13:19,840
in nuclear reactors

1880
01:13:25,270 --> 01:13:23,840
and um quite a bit of manufacturing as

1881
01:13:28,630 --> 01:13:25,280
well

1882
01:13:31,350 --> 01:13:28,640
yeah i so i actually went and did

1883
01:13:31,830 --> 01:13:31,360
i don't know not like a survey but i did

1884
01:13:33,990 --> 01:13:31,840
uh

1885
01:13:35,590 --> 01:13:34,000
just googling around to see what else is

1886
01:13:36,870 --> 01:13:35,600
out there and there's a lot of different

1887
01:13:38,550 --> 01:13:36,880
things there was

1888
01:13:40,310 --> 01:13:38,560

something that was i guess this isn't

1889
01:13:40,709 --> 01:13:40,320
directly in science but it was really

1890
01:13:44,830 --> 01:13:40,719
cool

1891
01:13:47,830 --> 01:13:44,840
it was getting it was sonifying

1892
01:13:51,110 --> 01:13:47,840
um the

1893
01:13:54,149 --> 01:13:51,120
to look at the population

1894
01:13:57,189 --> 01:13:54,159
density based on subway stop

1895
01:14:00,229 --> 01:13:57,199
in manhattan and so

1896
01:14:01,750 --> 01:14:00,239
you would so the way it it matched

1897
01:14:03,030 --> 01:14:01,760
through is that it was like you took a

1898
01:14:05,590 --> 01:14:03,040
train line and it would

1899
01:14:06,870 --> 01:14:05,600
so so there was a way easy way right

1900
01:14:08,950 --> 01:14:06,880
because

1901
01:14:10,790 --> 01:14:08,960
people are familiar with what the subway

1902
01:14:12,390 --> 01:14:10,800
system looks like in manhattan and

1903
01:14:14,070 --> 01:14:12,400
and then and so that would take you

1904
01:14:17,030 --> 01:14:14,080
through and it would change

1905
01:14:18,709 --> 01:14:17,040
it would change with what i remember was

1906
01:14:20,229 --> 01:14:18,719
population density but i think you could

1907
01:14:22,229 --> 01:14:20,239
also change it and have

1908
01:14:23,750 --> 01:14:22,239
like average numbers of different things

1909
01:14:27,030 --> 01:14:23,760
which was very cool

1910
01:14:33,990 --> 01:14:30,470
some um sonifications with

1911
01:14:37,030 --> 01:14:34,000
earthquakes um detection as well

1912
01:14:38,950 --> 01:14:37,040
um it comes up in a lot of places i

1913
01:14:41,510 --> 01:14:38,960

think it's worth mentioning too that

1914
01:14:42,229 --> 01:14:41,520
there are sonifications in just everyday

1915
01:14:43,750 --> 01:14:42,239
objects

1916
01:14:45,669 --> 01:14:43,760
that you use and you just probably

1917
01:14:47,750 --> 01:14:45,679
haven't thought of it as sonification

1918
01:14:49,669 --> 01:14:47,760
so i mean the heartbeat star we showed

1919
01:14:51,830 --> 01:14:49,679
is based on an ekg machine

1920
01:14:53,669 --> 01:14:51,840
but an ekg machine is a perfect example

1921
01:14:54,470 --> 01:14:53,679
of sonification being used in the

1922
01:14:56,470 --> 01:14:54,480
medical field

1923
01:14:57,990 --> 01:14:56,480
that you've definitely well you've

1924
01:14:59,430 --> 01:14:58,000
probably heard before so

1925
01:15:00,950 --> 01:14:59,440
lots of examples like that once you

1926
01:15:01,270 --> 01:15:00,960
start looking for it you'll you'll see

1927
01:15:03,669 --> 01:15:01,280
it

1928
01:15:05,669 --> 01:15:03,679
i mean even your microwave counting down

1929
01:15:08,830 --> 01:15:05,679
the number of seconds and ringing

1930
01:15:10,790 --> 01:15:08,840
is i some sort of form of sonification i

1931
01:15:14,550 --> 01:15:10,800
think

1932
01:15:17,270 --> 01:15:14,560
pot bubbling right

1933
01:15:18,870 --> 01:15:17,280
um yeah you're not paying attention but

1934
01:15:20,229 --> 01:15:18,880
you're hearing the pot bubbling on the

1935
01:15:22,709 --> 01:15:20,239
stove and you go ah

1936
01:15:25,030 --> 01:15:22,719
time to go you know take care of the the

1937
01:15:27,430 --> 01:15:25,040
pasta or whatever or when the teapot

1938
01:15:28,229 --> 01:15:27,440

uh whales yes exactly that's that's a

1939
01:15:30,070 --> 01:15:28,239
great one

1940
01:15:31,350 --> 01:15:30,080
or just pouring a glass of water you

1941
01:15:33,990 --> 01:15:31,360
hear it the sound

1942
01:15:35,669 --> 01:15:34,000
get higher pitched as you near the top

1943
01:15:37,189 --> 01:15:35,679
that's one a blind friend of mine

1944
01:15:39,110 --> 01:15:37,199
pointed out to me that i never thought

1945
01:15:39,990 --> 01:15:39,120
about but you can absolutely do a lot of

1946
01:15:41,830 --> 01:15:40,000
things and

1947
01:15:44,229 --> 01:15:41,840
the visualization makes it much more

1948
01:15:46,390 --> 01:15:44,239
accessible as well which is awesome

1949
01:15:48,630 --> 01:15:46,400
or the sonification rather well and this

1950
01:15:50,470 --> 01:15:48,640
is also the distinction that scott was

1951
01:15:53,669 --> 01:15:50,480
talking about at the very beginning

1952
01:15:57,270 --> 01:15:53,679
um the the tea kettle wailing

1953
01:15:58,870 --> 01:15:57,280
is could be is a sonification that water

1954
01:16:00,950 --> 01:15:58,880
is boiling and that's making a sound

1955
01:16:03,350 --> 01:16:00,960
happen but hearing the water boiling

1956
01:16:04,229 --> 01:16:03,360
that's not a sonification that's a sound

1957
01:16:07,110 --> 01:16:04,239
hearing the

1958
01:16:08,790 --> 01:16:07,120
the water pouring that's a sound so this

1959
01:16:11,510 --> 01:16:08,800
these

1960
01:16:12,470 --> 01:16:11,520
lines between sonification and sounds um

1961
01:16:15,830 --> 01:16:12,480
can be

1962
01:16:19,910 --> 01:16:15,840
especially when you get to um you know

1963
01:16:21,510 --> 01:16:19,920

a sound that is a real sound but isn't

1964
01:16:23,270 --> 01:16:21,520
actually audible to the human ear

1965
01:16:25,189 --> 01:16:23,280
being moved into a range that the human

1966
01:16:27,830 --> 01:16:25,199
ear can hear it because

1967
01:16:29,110 --> 01:16:27,840
it's its sound but you wouldn't have

1968
01:16:31,350 --> 01:16:29,120
been able to hear it without this

1969
01:16:33,430 --> 01:16:31,360
additional sonification component

1970
01:16:35,910 --> 01:16:33,440
such as the uh black hole merging the

1971
01:16:38,709 --> 01:16:35,920
chirp right

1972
01:16:40,229 --> 01:16:38,719
yeah yeah that's a perfect example yep

1973
01:16:42,310 --> 01:16:40,239
and the ekg is great too because it's

1974
01:16:43,990 --> 01:16:42,320
representing heartbeats

1975
01:16:45,590 --> 01:16:44,000
as sounds not actually listening to

1976
01:16:48,630 --> 01:16:45,600
sounds of the heart makes yeah

1977
01:16:50,470 --> 01:16:48,640
right so

1978
01:16:52,149 --> 01:16:50,480
the question that that's that i know

1979
01:16:52,790 --> 01:16:52,159
some of our audience has is is this

1980
01:16:54,790 --> 01:16:52,800
going to move

1981
01:16:56,470 --> 01:16:54,800
from doing sort of public outreach and

1982
01:16:58,790 --> 01:16:56,480
getting people to understand and

1983
01:17:01,350 --> 01:16:58,800
appreciate it to actually doing research

1984
01:17:02,310 --> 01:17:01,360
so will we ever have jody foster sitting

1985
01:17:04,630 --> 01:17:02,320
out with her

1986
01:17:05,990 --> 01:17:04,640
headphones on listening to the sounds of

1987
01:17:07,669 --> 01:17:06,000
the stuff listening to

1988
01:17:09,350 --> 01:17:07,679

the radio signals and actually doing

1989
01:17:11,510 --> 01:17:09,360
analysis which of course

1990
01:17:13,350 --> 01:17:11,520
never could happen because but for many

1991
01:17:14,470 --> 01:17:13,360
many reasons but what do you guys think

1992
01:17:17,110 --> 01:17:14,480
yeah i love contact

1993
01:17:18,070 --> 01:17:17,120
that's a great question and um we have

1994
01:17:20,950 --> 01:17:18,080
that now

1995
01:17:22,149 --> 01:17:20,960
so one important point of the project is

1996
01:17:23,990 --> 01:17:22,159
our goal is to make

1997
01:17:25,990 --> 01:17:24,000
sonification that is useful for research

1998
01:17:27,669 --> 01:17:26,000
purposes a lot of people make

1999
01:17:28,470 --> 01:17:27,679
sonification for things like press

2000
01:17:31,189 --> 01:17:28,480
releases

2001
01:17:33,990 --> 01:17:31,199
or presentations or art exhibits and

2002
01:17:37,590 --> 01:17:34,000
they really massage and change the sound

2003
01:17:39,189 --> 01:17:37,600
to be you know a certain

2004
01:17:40,870 --> 01:17:39,199
representation that works well for their

2005
01:17:43,030 --> 01:17:40,880
particular case but

2006
01:17:45,030 --> 01:17:43,040
our software is designed to enable real

2007
01:17:46,470 --> 01:17:45,040
research guts and everything so

2008
01:17:47,910 --> 01:17:46,480
if it sounds ugly because the data is

2009
01:17:49,270 --> 01:17:47,920
ugly we need to make sure that's

2010
01:17:51,189 --> 01:17:49,280
maintained and

2011
01:17:53,189 --> 01:17:51,199
we are also this is a very important

2012
01:17:56,070 --> 01:17:53,199
point we are working one-on-one

2013
01:17:58,149 --> 01:17:56,080

with many blind and low-vision

2014
01:17:59,750 --> 01:17:58,159
participants who are testing and giving

2015
01:18:02,070 --> 01:17:59,760
us feedback

2016
01:18:02,790 --> 01:18:02,080
on our project so we do have you know

2017
01:18:04,630 --> 01:18:02,800
several

2018
01:18:06,070 --> 01:18:04,640
blind low vision you know astronomy

2019
01:18:07,910 --> 01:18:06,080
students physics students computer

2020
01:18:09,510 --> 01:18:07,920
science students from around the world

2021
01:18:10,950 --> 01:18:09,520
working with us to make sure that this

2022
01:18:13,270 --> 01:18:10,960
is not only

2023
01:18:14,709 --> 01:18:13,280
a good portrayal of research data but

2024
01:18:15,990 --> 01:18:14,719
also something that's useful for them

2025
01:18:18,390 --> 01:18:16,000
because that's ultimately what this is

2026
01:18:19,830 --> 01:18:18,400
for not for us that was something that

2027
01:18:21,430 --> 01:18:19,840
came up very clearly

2028
01:18:23,430 --> 01:18:21,440
through some of the usability testing

2029
01:18:25,910 --> 01:18:23,440
i've been doing but

2030
01:18:28,070 --> 01:18:25,920
one person in particular who i think had

2031
01:18:29,669 --> 01:18:28,080
studied science in college but ended up

2032
01:18:30,950 --> 01:18:29,679
not being able to enter the field

2033
01:18:32,790 --> 01:18:30,960
because she was blind and

2034
01:18:34,630 --> 01:18:32,800
there's just too many barriers for her

2035
01:18:36,070 --> 01:18:34,640
so she wasn't able to pursue it as a

2036
01:18:37,110 --> 01:18:36,080
career unfortunately

2037
01:18:39,590 --> 01:18:37,120
and so when i was going through this

2038
01:18:40,790 --> 01:18:39,600

usability testing with her and then

2039
01:18:42,870 --> 01:18:40,800
at first she didn't realize she was

2040
01:18:45,750 --> 01:18:42,880
thinking it was these massaged uh

2041
01:18:46,630 --> 01:18:45,760
outreach style sonifications but when

2042
01:18:48,229 --> 01:18:46,640
once she like

2043
01:18:50,550 --> 01:18:48,239
realized that this was software that she

2044
01:18:53,590 --> 01:18:50,560
would be able to use to generate

2045
01:18:55,990 --> 01:18:53,600
the the sonifications herself it like

2046
01:18:57,110 --> 01:18:56,000
she's so excited because that means you

2047
01:18:58,149 --> 01:18:57,120
can do research

2048
01:19:00,550 --> 01:18:58,159
if you're listening to something

2049
01:19:01,910 --> 01:19:00,560
someone's already massaged that means

2050
01:19:03,189 --> 01:19:01,920
that all the research has kind of been

2051
01:19:04,870 --> 01:19:03,199
done right like anything

2052
01:19:06,790 --> 01:19:04,880
there is to know about that is probably

2053
01:19:08,229 --> 01:19:06,800
known by the person who put that

2054
01:19:09,590 --> 01:19:08,239
sonification out there

2055
01:19:11,910 --> 01:19:09,600
but the fact that we built this as

2056
01:19:13,189 --> 01:19:11,920
software means that people can sonify

2057
01:19:15,270 --> 01:19:13,199
their own data

2058
01:19:16,310 --> 01:19:15,280
and study it and then do re real

2059
01:19:18,229 --> 01:19:16,320
research with it

2060
01:19:20,790 --> 01:19:18,239
so that is the thing to really focus on

2061
01:19:24,229 --> 01:19:20,800
here this is enabling research

2062
01:19:25,510 --> 01:19:24,239
and one specific um use that came up in

2063
01:19:28,070 --> 01:19:25,520

another usability

2064
01:19:29,189 --> 01:19:28,080
test that jen did was with a current

2065
01:19:30,950 --> 01:19:29,199
undergraduate

2066
01:19:33,430 --> 01:19:30,960
who said that something that she'd been

2067
01:19:35,750 --> 01:19:33,440
struggling with she's working

2068
01:19:36,709 --> 01:19:35,760
on looking at actually light curve data

2069
01:19:40,709 --> 01:19:36,719
like what we're

2070
01:19:43,030 --> 01:19:40,719
using was that

2071
01:19:44,790 --> 01:19:43,040
they were running it through a pipeline

2072
01:19:46,310 --> 01:19:44,800
process you know and and doing their

2073
01:19:48,070 --> 01:19:46,320
analysis on it

2074
01:19:49,750 --> 01:19:48,080
and she would do that and then someone

2075
01:19:51,350 --> 01:19:49,760
who is sighted would come in and look at

2076
01:19:52,470 --> 01:19:51,360
the light curve and say well that that

2077
01:19:55,830 --> 01:19:52,480
light curve clearly has

2078
01:19:57,030 --> 01:19:55,840
problems and she couldn't tell and she

2079
01:20:00,070 --> 01:19:57,040
was like well with this

2080
01:20:01,830 --> 01:20:00,080
like they would they wouldn't

2081
01:20:03,590 --> 01:20:01,840
she was like well if i could sonify it

2082
01:20:05,189 --> 01:20:03,600
then i could listen to it and

2083
01:20:07,430 --> 01:20:05,199
you know i wouldn't i would still have

2084
01:20:09,830 --> 01:20:07,440
to go through the

2085
01:20:11,430 --> 01:20:09,840
analysis that's what the research is but

2086
01:20:11,830 --> 01:20:11,440
we're able to be able to do that check

2087
01:20:15,990 --> 01:20:11,840
that

2088
01:20:16,950 --> 01:20:16,000

bring up the light curving you can and

2089
01:20:19,430 --> 01:20:16,960
you go oh well that's

2090
01:20:20,470 --> 01:20:19,440
clearly garbage because it just doesn't

2091
01:20:22,149 --> 01:20:20,480
look real

2092
01:20:23,510 --> 01:20:22,159
um you know and that wasn't accessible

2093
01:20:25,830 --> 01:20:23,520
to her but you would be able to hear

2094
01:20:28,870 --> 01:20:25,840
that because it would just sound

2095
01:20:31,189 --> 01:20:28,880
weird and different and and so that you

2096
01:20:32,709 --> 01:20:31,199
know is maybe not as exciting as jody

2097
01:20:33,350 --> 01:20:32,719
foster being like oh i've discovered

2098
01:20:35,590 --> 01:20:33,360
aliens

2099
01:20:37,510 --> 01:20:35,600
but that's an important use case because

2100
01:20:39,990 --> 01:20:37,520
it's these mundane things

2101
01:20:41,910 --> 01:20:40,000
that make everyday research harder is

2102
01:20:44,790 --> 01:20:41,920
like when you realize you just spent an

2103
01:20:46,310 --> 01:20:44,800
hour running a you know piece of data

2104
01:20:47,590 --> 01:20:46,320
through a pipeline that's useless

2105
01:20:49,669 --> 01:20:47,600
because the data was

2106
01:20:50,950 --> 01:20:49,679
bad to begin with i mean we all do that

2107
01:20:52,470 --> 01:20:50,960
when we

2108
01:20:53,910 --> 01:20:52,480
have everything at our fingertips

2109
01:20:54,629 --> 01:20:53,920
imagine how often you do that when

2110
01:20:59,270 --> 01:20:54,639
you're

2111
01:21:02,790 --> 01:21:01,750
and um do you guys have any ideas of

2112
01:21:05,110 --> 01:21:02,800
possibly

2113
01:21:07,110 --> 01:21:05,120

you know citizen science oh sourcing it

2114
01:21:08,470 --> 01:21:07,120
for these huge data sets that might need

2115
01:21:10,390 --> 01:21:08,480
to be sonified

2116
01:21:11,990 --> 01:21:10,400
that because it sounds like you could

2117
01:21:14,790 --> 01:21:12,000
train the public to listen

2118
01:21:15,510 --> 01:21:14,800
for certain things and identify you know

2119
01:21:16,790 --> 01:21:15,520
because

2120
01:21:18,310 --> 01:21:16,800
you know citizen science is great for

2121
01:21:19,270 --> 01:21:18,320
looking for those needles in a haystack

2122
01:21:21,189 --> 01:21:19,280
and if you can

2123
01:21:22,550 --> 01:21:21,199
uh train people you have any thoughts on

2124
01:21:24,629 --> 01:21:22,560
that on that front

2125
01:21:26,390 --> 01:21:24,639
yeah one of the things one of the

2126
01:21:27,990 --> 01:21:26,400
projects in the back of my mind is to

2127
01:21:29,189 --> 01:21:28,000
make a test dot radio

2128
01:21:31,270 --> 01:21:29,199
i don't know if people would be

2129
01:21:32,709 --> 01:21:31,280
interested in it but uh i've been

2130
01:21:33,750 --> 01:21:32,719
thinking about well we can create and

2131
01:21:35,910 --> 01:21:33,760
make it interesting

2132
01:21:37,590 --> 01:21:35,920
we can maybe make a spotify channel just

2133
01:21:38,390 --> 01:21:37,600
plays all these light curves so i'm

2134
01:21:40,950 --> 01:21:38,400
actually working

2135
01:21:42,229 --> 01:21:40,960
today on preparing to release something

2136
01:21:44,149 --> 01:21:42,239
like 19

2137
01:21:46,629 --> 01:21:44,159
million light curves from the test

2138
01:21:49,430 --> 01:21:46,639

mission 19 million stars

2139
01:21:50,229 --> 01:21:49,440
and no one ever will be able to look at

2140
01:21:54,550 --> 01:21:50,239
them

2141
01:21:56,870 --> 01:21:54,560
listen to some while we're working or in

2142
01:21:57,910 --> 01:21:56,880
the car or taking a shower or whatever

2143
01:21:59,510 --> 01:21:57,920
we might be able to make some really

2144
01:22:00,790 --> 01:21:59,520
cool discoveries so yeah there's there's

2145
01:22:02,229 --> 01:22:00,800
people there are also other groups

2146
01:22:03,750 --> 01:22:02,239
looking at um xenoverse

2147
01:22:05,750 --> 01:22:03,760
a lot of our audience might be familiar

2148
01:22:07,590 --> 01:22:05,760
with xenoverse um there's at least one

2149
01:22:09,590 --> 01:22:07,600
or two groups looking to incorporate

2150
01:22:10,790 --> 01:22:09,600
sound as a xenoverse project and we

2151
01:22:12,629 --> 01:22:10,800
could do the same thing as well

2152
01:22:14,310 --> 01:22:12,639
if there's interest and resources to do

2153
01:22:14,790 --> 01:22:14,320
so yeah we really want to engage the

2154
01:22:16,229 --> 01:22:14,800
public

2155
01:22:18,390 --> 01:22:16,239
and also i think there was a question

2156
01:22:20,390 --> 01:22:18,400
about um being able to

2157
01:22:22,070 --> 01:22:20,400
um contribute if you know if you know

2158
01:22:23,910 --> 01:22:22,080
software this is open source

2159
01:22:25,510 --> 01:22:23,920
so if if you really want to get in

2160
01:22:26,709 --> 01:22:25,520
interested in a volunteer basis and you

2161
01:22:28,229 --> 01:22:26,719
know how to code

2162
01:22:29,990 --> 01:22:28,239
it's open source you can do a pull

2163
01:22:31,510 --> 01:22:30,000

request um it's

2164
01:22:36,470 --> 01:22:31,520
we're open for business as it were but

2165
01:22:39,590 --> 01:22:38,310
we're open for science we're open to

2166
01:22:41,350 --> 01:22:39,600
science and contribution and

2167
01:22:44,070 --> 01:22:41,360
collaboration that's what it's all about

2168
01:22:45,030 --> 01:22:44,080
okay um clara there was a question that

2169
01:22:47,990 --> 01:22:45,040
uh sort of

2170
01:22:48,390 --> 01:22:48,000
asked about what would i programming

2171
01:22:50,870 --> 01:22:48,400
thing

2172
01:22:52,310 --> 01:22:50,880
skills do i need to do astronomy and

2173
01:22:54,870 --> 01:22:52,320
i've actually gotten that question

2174
01:22:55,350 --> 01:22:54,880
a lot from when i give career talks for

2175
01:22:59,430 --> 01:22:55,360
for

2176
01:23:01,990 --> 01:22:59,440
do astronomy stuff

2177
01:23:03,110 --> 01:23:02,000
you're you're doing python um can you

2178
01:23:04,790 --> 01:23:03,120
just uh

2179
01:23:06,709 --> 01:23:04,800
give an idea of what people would want

2180
01:23:09,270 --> 01:23:06,719
to study in terms of these the

2181
01:23:11,270 --> 01:23:09,280
programming languages and why

2182
01:23:12,470 --> 01:23:11,280
yeah i mean so if you want to get into

2183
01:23:14,470 --> 01:23:12,480
astronomy

2184
01:23:15,669 --> 01:23:14,480
definitely python is a great place to

2185
01:23:19,669 --> 01:23:15,679
start i mean i

2186
01:23:21,189 --> 01:23:19,679
recommend people interested to get into

2187
01:23:22,310 --> 01:23:21,199
i recommend that people start with

2188
01:23:23,830 --> 01:23:22,320

python when they're starting with

2189
01:23:26,870 --> 01:23:23,840
programming languages

2190
01:23:29,590 --> 01:23:26,880
and i recommend this for

2191
01:23:31,350 --> 01:23:29,600
basically one very important reason

2192
01:23:33,189 --> 01:23:31,360
which is that it is an incredibly

2193
01:23:36,070 --> 01:23:33,199
popular language and there is an

2194
01:23:37,830 --> 01:23:36,080
abundance of information about doing

2195
01:23:40,629 --> 01:23:37,840
things in python on the internet

2196
01:23:43,030 --> 01:23:40,639
i noticed this very much i'm a i'm a

2197
01:23:46,229 --> 01:23:43,040
python programmer and i'm a c programmer

2198
01:23:47,350 --> 01:23:46,239
and i can vary and i'm very good at both

2199
01:23:49,430 --> 01:23:47,360
of those languages

2200
01:23:51,430 --> 01:23:49,440
and i can easily get myself into a

2201
01:23:53,510 --> 01:23:51,440
situation and see

2202
01:23:55,510 --> 01:23:53,520
where i've hit a problem and i go to the

2203
01:23:57,590 --> 01:23:55,520
internet and i can't find anything

2204
01:23:59,189 --> 01:23:57,600
and i just have to sort of bust my way

2205
01:24:00,950 --> 01:23:59,199
through it and i'm experienced enough

2206
01:24:04,229 --> 01:24:00,960
now that i can do it

2207
01:24:05,990 --> 01:24:04,239
but i've almost never got myself in that

2208
01:24:07,910 --> 01:24:06,000
situation with python

2209
01:24:09,350 --> 01:24:07,920
even with the really weird complicated

2210
01:24:10,870 --> 01:24:09,360
things there's someone else who has done

2211
01:24:11,189 --> 01:24:10,880
it and it was put it on the internet and

2212
01:24:15,510 --> 01:24:11,199
that

2213
01:24:18,149 --> 01:24:15,520

makes learning it a incredibly

2214
01:24:19,990 --> 01:24:18,159
more rewarding experience and then the

2215
01:24:21,750 --> 01:24:20,000
other thing for astronomy particularly

2216
01:24:24,950 --> 01:24:21,760
if you're not

2217
01:24:26,310 --> 01:24:24,960
currently in school in a traditional

2218
01:24:28,310 --> 01:24:26,320
physics program with a lot of people

2219
01:24:30,390 --> 01:24:28,320
around you is there is a nice

2220
01:24:31,669 --> 01:24:30,400
astronomical community built around

2221
01:24:32,950 --> 01:24:31,679
software

2222
01:24:35,110 --> 01:24:32,960
if you're interested in getting into

2223
01:24:37,990 --> 01:24:35,120
things i recommend checking out astro pi

2224
01:24:39,110 --> 01:24:38,000
it's the main python package for

2225
01:24:40,950 --> 01:24:39,120
astronomy

2226
01:24:42,390 --> 01:24:40,960
but more than that it is also an

2227
01:24:44,390 --> 01:24:42,400
ecosystem there is

2228
01:24:45,430 --> 01:24:44,400
a it's a great community they run

2229
01:24:48,070 --> 01:24:45,440
community events

2230
01:24:49,030 --> 01:24:48,080
they run hack days they run hackathons

2231
01:24:51,430 --> 01:24:49,040
some of which

2232
01:24:53,189 --> 01:24:51,440
they run workshops that are really in

2233
01:24:55,189 --> 01:24:53,199
invest and they're really invested in

2234
01:24:57,189 --> 01:24:55,199
bringing people into the community

2235
01:24:58,709 --> 01:24:57,199
they have an extensive tagging system on

2236
01:25:00,950 --> 01:24:58,719
their issues so you can look for things

2237
01:25:03,270 --> 01:25:00,960
that are easy

2238
01:25:05,430 --> 01:25:03,280

they have a whole astropyler network

2239
01:25:08,390 --> 01:25:05,440
that that helps you learn

2240
01:25:09,030 --> 01:25:08,400
how to use astrophy but it can also

2241
01:25:12,790 --> 01:25:09,040
teach you

2242
01:25:16,070 --> 01:25:12,800
a lot about astronomy

2243
01:25:18,070 --> 01:25:16,080
i have an undergraduate degree in

2244
01:25:19,750 --> 01:25:18,080
astronomy and now i have more experience

2245
01:25:21,750 --> 01:25:19,760
in astronomy but when i started working

2246
01:25:24,870 --> 01:25:21,760
at space telescope my python abilities

2247
01:25:28,950 --> 01:25:24,880
outstripped my astronomy abilities

2248
01:25:31,350 --> 01:25:28,960
and so i would go to these tutorials and

2249
01:25:33,270 --> 01:25:31,360
and yeah i you know they're teaching me

2250
01:25:35,030 --> 01:25:33,280
how to manipulate tables and how to use

2251
01:25:36,709 --> 01:25:35,040
this particular astro pi package but

2252
01:25:38,470 --> 01:25:36,719
that wasn't really the hard part for me

2253
01:25:42,229 --> 01:25:38,480
they were also teaching me

2254
01:25:45,350 --> 01:25:42,239
you know how to

2255
01:25:47,430 --> 01:25:45,360
um analyze a star

2256
01:25:48,950 --> 01:25:47,440
how to analyze a spectra how to do all

2257
01:25:50,310 --> 01:25:48,960
these different things so i think that's

2258
01:25:52,229 --> 01:25:50,320
a really great place to start there are

2259
01:25:54,390 --> 01:25:52,239
other languages that are useful

2260
01:25:56,390 --> 01:25:54,400
for astronomy but the barrier to entry

2261
01:25:58,709 --> 01:25:56,400
is lower for python and you'll get to

2262
01:26:00,390 --> 01:25:58,719
interact with astronomers basically as

2263
01:26:01,990 --> 01:26:00,400

soon as you want to

2264
01:26:05,030 --> 01:26:02,000
and that's a great point about the

2265
01:26:07,110 --> 01:26:05,040
software ecosystem that enables science

2266
01:26:08,790 --> 01:26:07,120
uh there's so much you know more than

2267
01:26:10,629 --> 01:26:08,800
just you know everyone thinks of

2268
01:26:12,310 --> 01:26:10,639
astronomers looking at using the

2269
01:26:15,590 --> 01:26:12,320
telescope and getting data

2270
01:26:16,629 --> 01:26:15,600
uh there's such an amazing uh ecosystem

2271
01:26:18,229 --> 01:26:16,639
of of

2272
01:26:19,669 --> 01:26:18,239
other things that have to happen to make

2273
01:26:22,629 --> 01:26:19,679
science happen

2274
01:26:23,270 --> 01:26:22,639
i think it would be tutorials out there

2275
01:26:25,270 --> 01:26:23,280
that use

2276
01:26:28,229 --> 01:26:25,280
actual astronomical data from those

2277
01:26:31,510 --> 01:26:28,239
telescopes so it can also be a quick way

2278
01:26:33,910 --> 01:26:31,520
to get to see the same data that all of

2279
01:26:35,830 --> 01:26:33,920
the astronomers are looking at

2280
01:26:37,750 --> 01:26:35,840
all right we're getting close to 9 30.

2281
01:26:40,390 --> 01:26:37,760
grant is there any one last question or

2282
01:26:42,149 --> 01:26:40,400
or do you think we're done here we are

2283
01:26:45,350 --> 01:26:42,159
through the questions that the

2284
01:26:47,830 --> 01:26:45,360
chat has and yeah

2285
01:26:50,629 --> 01:26:47,840
i just think scott if you wouldn't mind

2286
01:26:52,070 --> 01:26:50,639
just dropping some of the links

2287
01:26:54,470 --> 01:26:52,080
or the because there's some people

2288
01:26:58,229 --> 01:26:54,480

asking about astro pie and whatnot

2289
01:27:00,790 --> 01:26:58,239
oh yeah i will remember that there are

2290
01:27:01,990 --> 01:27:00,800
like for this lecture there are

2291
01:27:04,950 --> 01:27:02,000
thousands of people

2292
01:27:06,550 --> 01:27:04,960
all over the world doing this sort of

2293
01:27:08,310 --> 01:27:06,560
stuff and they would love nothing more

2294
01:27:09,430 --> 01:27:08,320
than for you to help explore space with

2295
01:27:12,550 --> 01:27:09,440
them like

2296
01:27:15,669 --> 01:27:12,560
become a part of something awesome

2297
01:27:17,270 --> 01:27:15,679
yeah so like there's no

2298
01:27:19,270 --> 01:27:17,280
there's no upfront there's no getting

2299
01:27:20,709 --> 01:27:19,280
into it you just find some cool people

2300
01:27:22,550 --> 01:27:20,719
and

2301
01:27:23,990 --> 01:27:22,560
yeah i encourage everyone to you know

2302
01:27:24,709 --> 01:27:24,000
sign up for our mailing list we also

2303
01:27:26,310 --> 01:27:24,719
have uh

2304
01:27:28,070 --> 01:27:26,320
the astronomify home page which i will

2305
01:27:30,550 --> 01:27:28,080
link in the chat as well

2306
01:27:32,390 --> 01:27:30,560
um has all of our contact info it's got

2307
01:27:34,950 --> 01:27:32,400
we have a mailing list we have a

2308
01:27:35,990 --> 01:27:34,960
uh email that you can send to our group

2309
01:27:38,550 --> 01:27:36,000
i'm on twitter

2310
01:27:39,750 --> 01:27:38,560
um which are on the front page there get

2311
01:27:41,030 --> 01:27:39,760
in touch we want to reach out to

2312
01:27:41,669 --> 01:27:41,040
everybody and do our best to work

2313
01:27:43,350 --> 01:27:41,679

together

2314
01:27:45,350 --> 01:27:43,360
this is this is not a secret project

2315
01:27:47,430 --> 01:27:45,360
this is open for everyone

2316
01:27:48,709 --> 01:27:47,440
um to be able to benefit from especially

2317
01:27:49,830 --> 01:27:48,719
people who are blind on low vision but

2318
01:27:51,350 --> 01:27:49,840
also everyone else too

2319
01:27:53,830 --> 01:27:51,360
it's just a lot of fun and it's really

2320
01:27:54,390 --> 01:27:53,840
cool all right jen did you have anything

2321
01:27:57,430 --> 01:27:54,400
to add

2322
01:28:00,709 --> 01:27:57,440
uh for our before we go no

2323
01:28:02,709 --> 01:28:00,719
just go to our website join us i've got

2324
01:28:04,229 --> 01:28:02,719
one thing to add which is if you are

2325
01:28:06,149 --> 01:28:04,239
watching this recorded

2326
01:28:07,510 --> 01:28:06,159
please still answer the survey these

2327
01:28:09,669 --> 01:28:07,520
guys are still

2328
01:28:10,870 --> 01:28:09,679
like keeping track of it and it helps

2329
01:28:12,790 --> 01:28:10,880
them out so

2330
01:28:14,390 --> 01:28:12,800
yeah every survey response that you get

2331
01:28:15,030 --> 01:28:14,400
i will get an email and i will be

2332
01:28:17,270 --> 01:28:15,040
checking it

2333
01:28:18,390 --> 01:28:17,280
and potentially will be you know it'll

2334
01:28:20,149 --> 01:28:18,400
be impacting

2335
01:28:21,669 --> 01:28:20,159
work going forward and maybe we'll even

2336
01:28:23,830 --> 01:28:21,679
be writing some papers with it in the

2337
01:28:26,950 --> 01:28:23,840
future so really appreciate it

2338
01:28:27,990 --> 01:28:26,960

all right well jen scott and clara thank

2339
01:28:30,629 --> 01:28:28,000
you very much

2340
01:28:31,990 --> 01:28:30,639
we really appreciate this wonderful talk

2341
01:28:34,709 --> 01:28:32,000
uh to our audience

2342
01:28:35,910 --> 01:28:34,719
uh december 1st will be the next public

2343
01:28:39,110 --> 01:28:35,920
lecture series

2344
01:28:42,870 --> 01:28:39,120
shaping galaxies with super massive

2345
01:28:45,510 --> 01:28:42,880
black holes uh mr rovolsky

2346
01:28:47,830 --> 01:28:45,520
we'll see you then thank you and have a